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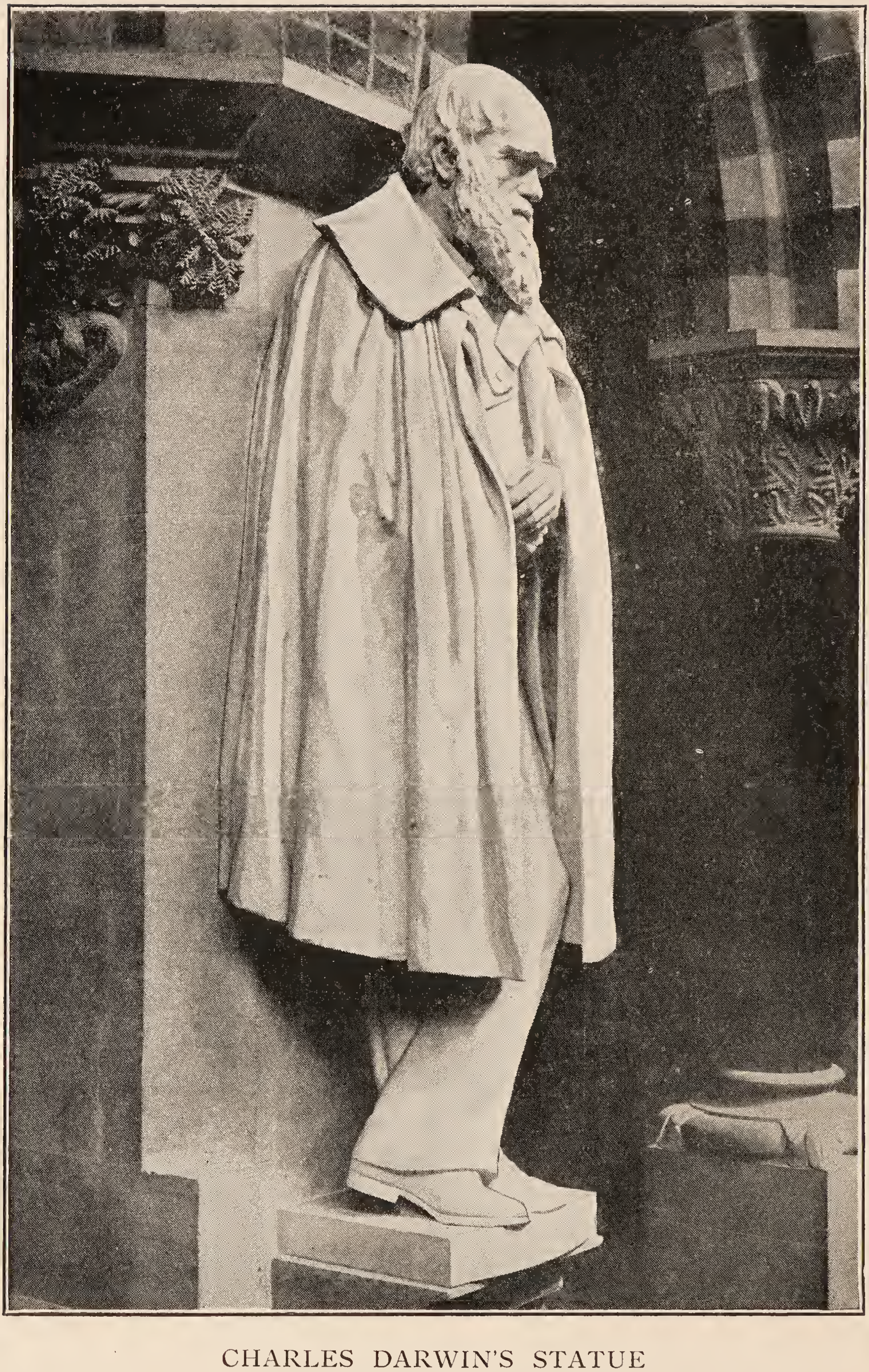

CHARLES DARWIN'S STATUE

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8600

A PICTURE BOOK
OF
EVOLUTION

BY
DENNIS HIRD, M.A., J.P.
Author of "An Easy Outline of Evolution," "The Believing Bishop," "Toddle Island," etc.

PART II.

CONTAINING LESSONS FROM
COMPARATIVE ANATOMY AND EMBRYOLOGY,
AND GIVING THE PEDIGREE OF MAN

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INTRODUCTION

HAD I known that Professor Haeckel's *Evolution of Man* would be so soon reprinted, and the two volumes sold for a shilling, I should certainly not have prepared *The Picture Book of Evolution.*

I can only hope, as my book is merely a few first steps, that it may help some to read Darwin and Haeckel who otherwise might have found them too difficult.

My warmest thanks are given to Mr. Herbert S. Leon for his generous help in procuring the illustrations for this *Picture Book.* Unless Mr. Leon had borne the expense of making so many blocks, these two books could not have been so fully illustrated.

I also thank Professor G. H. Darwin, of Cambridge, for so kindly lending me the photographs of his grandfather and his mother, and allowing me to use them.

I thank Professor Arthur Thomson, of Oxford, for a copy of his original photograph of the most interesting human fœtus (Fig. 99).

And, again, I heartily thank Mrs. Romanes for permission to use the excellent pictures from the late Professor Romanes' *Darwin and After Darwin.*

D. H.

Bletchley, Bucks.

November 12th, 1907.

CHAPTER I.

PRELIMINARY POINTS

"Conviction depends on more than intelligence, often on emotional vested interests."

ATTITUDE.

MOST minds are hostile to new ideas. Such invaders are viewed with anger or alarm. We should not wonder at this, perhaps, if we could bear in mind that the human brain is a comparatively new instrument, and at present very imperfectly developed. Further, as all intelligence results from the action of outside forces upon the nervous system, it is manifest that, when first a new set of forces acts upon the brain, there must be something of the nature of a shock.

This explains why it is that the *attitude* of the student so largely determines his power to receive new ideas. Many people have enough ability to understand "Evolution," were it not for the fact that they approach the subject with a murderous desire to destroy it rather than to comprehend it.

It is therefore of the utmost importance that we should begin this inquiry in the easiest and simplest manner. To assist the brain to the right attitude we must be satisfied to take first a few well-known facts and avoid a few of the oldest errors.

He who has been taught incorrect and fictitious surmises about the beginnings of the earth and man has a host of enemies in his own brain. These enemies contest every approach of truth, and constitute a far more formidable barrier than sheer ignorance. So long, however, as any explanation or no explanation of the world is deemed good enough for children, these enemies will drag the human race in captive chains. No man can redeem these captives.

But for the open-minded inquirer many mysteries can be solved, if he will begin by climbing the lowest steps to the temple of light.

While we are trying to climb the lowest steps we shall do well to ponder often upon these words of Herbert Spencer :—

" Early ideas are not usually true ideas. Undeveloped intellect, be it that of an individual or that of the race, forms conclusions which require to be revised and re-revised, before they reach a tolerable correspondence with realities. Were it otherwise, there would be no discovery, no increase of intelligence. What we call the progress of knowledge is the bringing of thoughts into harmony with things ; and it implies that the first thoughts are either wholly out of harmony with things or in very incomplete harmony with them.

" If illustrations be needed, the history of every science furnishes them. The primitive notions of mankind as to the structure of the heavens were wrong ; and the notions which replaced them were successively less wrong. The original belief respecting the form of the earth was wrong, and this wrong belief survived through the first civilisations "—(Sect. 110, vol. i., *Principles of Biology*).

Many people are still satisfied with the " early ideas " of man when he was but little better than a savage. They still speak of comets, witches, and ghosts in the ignorant and comic manner of the lowest races. Such people are thousands of years behind science, and to them half the world has no meaning.

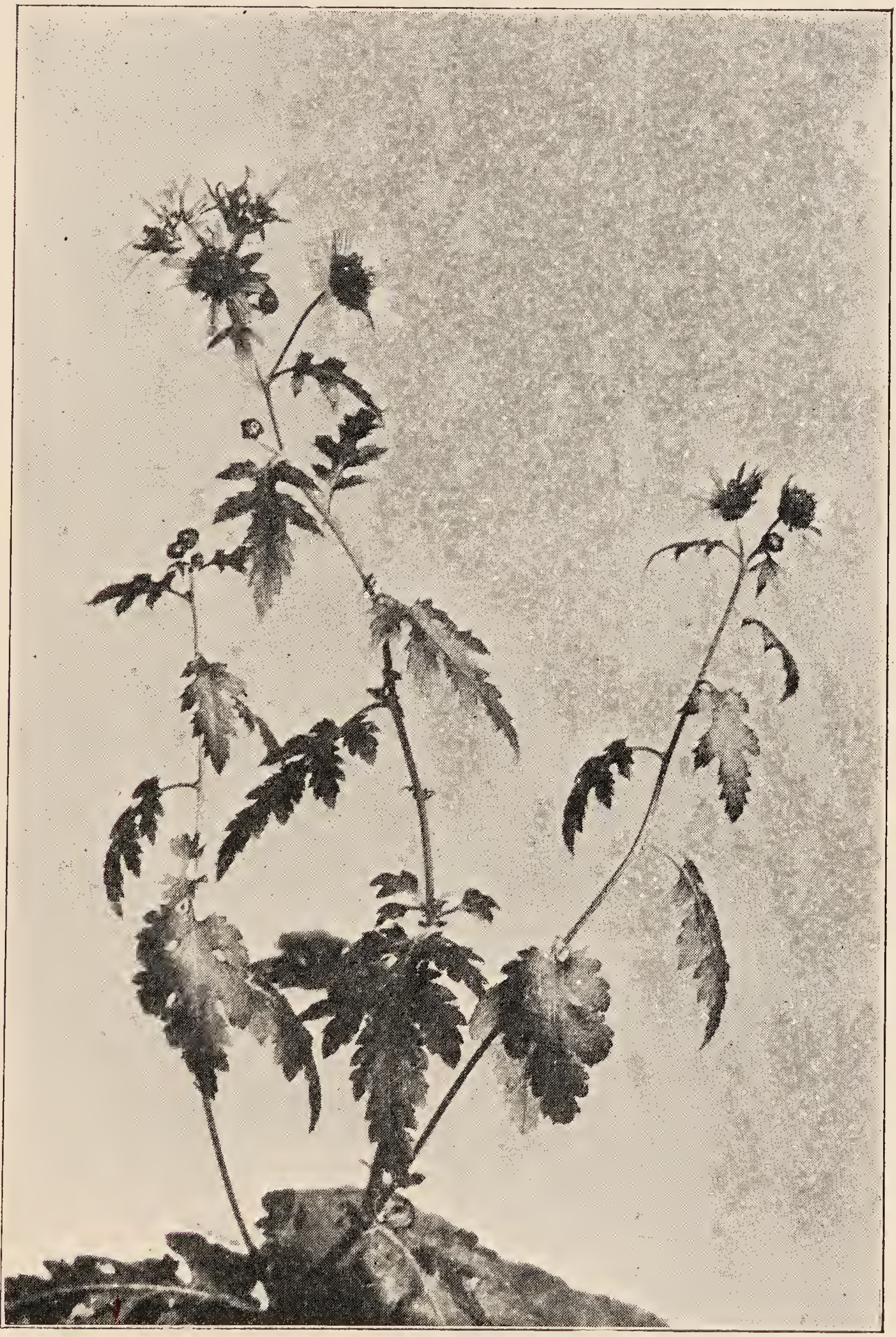

FIG. 1.—Chrysanthemum Indicum.

One of these "early ideas," which is held by some, is that species are fixed, which means that each species was separately created, and has remained the same through all time. The life of man is so short that nobody has seen one species develop from another species. But there are many varieties which he can see, and he can also note that these varieties often re-appear in the offspring or descendants. From such varieties, frequently

FIG. 2.—Chrysanthemum.

repeated and increased in the long course of ages, all species may have arisen.

SELECTION.

If you look at Fig. 1, you see the ancestor of the modern chrysanthemum (Fig. 2). Fig. 1 is the Chrysanthemum Indicum; but few people would be able to recognise that it was a chrysanthemum of any kind. In Fig. 2 we see what can be done by seizing upon variations and propagating the plants which favour these variations.

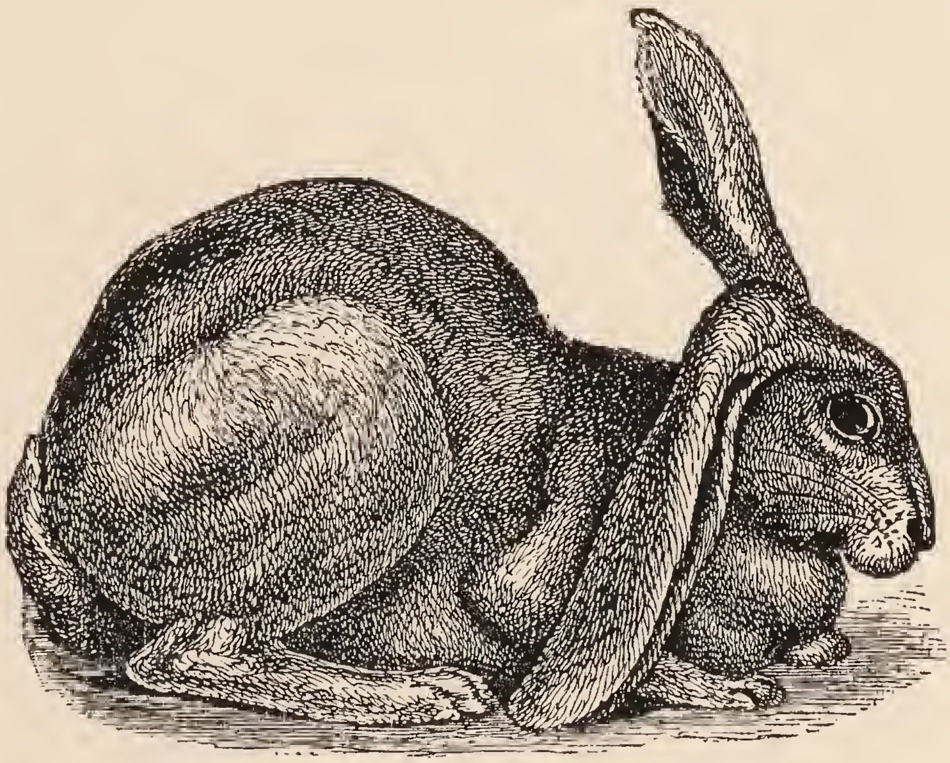

FIG. 3.—Half-lop Rabbit.

The half-lop rabbit (Fig. 3) shows us the law in a slightly different way, but it is very striking and simple. The law by which the offspring of a plant or animal reproduces some variation or peculiarity of the parent is called the law of heredity.

Now, the peculiar beauty of the modern chrysanthemum, shown in Fig. 2, has been produced by man's selecting the varieties he wanted time after time, and so, as it were, adding up many little variations, till he produced a variety very unlike the original. This variety is now so far permanent that it can be propagated with a fair degree of certainty.

In the case of Fig. 3 the half-lop (or drooping of one ear) is an abnormal variation, which some would call merely an accidental variation; but it took someone's fancy, and so by artificial selection it has become constant in breed. If you think this over carefully and often, it will become a revelation of a mode of modifying animals which has been in operation millions of years, and so the doctrine of evolution or modification by descent will be more easily understood.

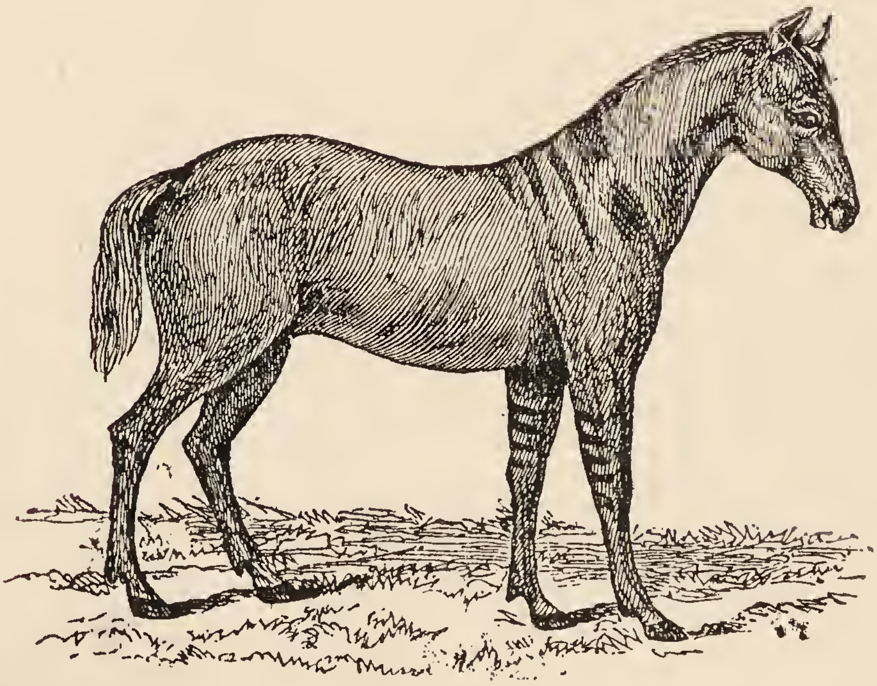

FIG. 4.—Devonshire Pony, showing ancestral stripes.

REVERSION.

As we have touched upon this law by which variations or peculiar features of parents are reproduced in the offspring, we may glance at another form of it. In Fig. 4 you see a pony with peculiar stripes on its shoulders and fore legs. These stripes are really the marks of its wild ancestors.

Such marks will sometimes reappear, though neither the parents nor the grandparents had them. This form of variation is called "atavism" (from Latin *ătăvus*, the father of the great-great-grandfather, and so means a remote ancestor). Another term for it is "reversion," or, as breeders often say of such an animal, "it has thrown back." All kinds of animals show this very remarkable law. A lizard, in growing a new tail to replace one that has been lost, has been known to grow one with *scales* like those of an ancestral species.

A blue rock-pigeon (see Fig. 177, Part I.), like the primitive rock-dove, sometimes turns up unexpectedly in a pure breed.

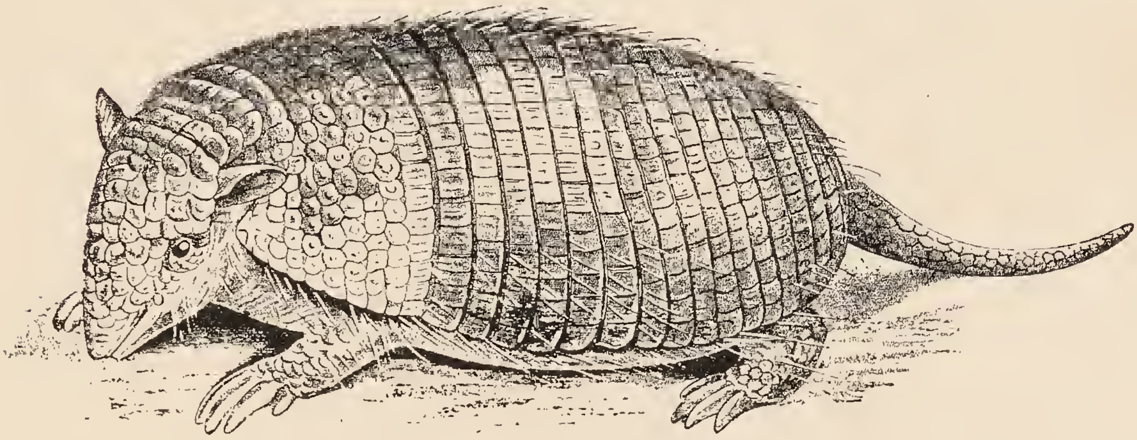

FIG. 5.—Armadillo.

Children born *during famine* sometimes show reversion to an early ancestor, and "some types of criminal and insane persons are to be thus regarded."

The origin of the marks on the pony in Fig. 4 is very interesting. It appears to be the same as the origin of dapples on horses. Now, it is well known that *all* mammals come from a group of reptiles, which, of course, were scaly creatures. The armadillo, Fig. 5, shows this arrangement. Hairs can be seen growing between the scales. The hair used to grow round the scales, or between the rows of scales. In the former case, when the scales were lost, the hair grew a different colour and formed dapples; in the latter case the same thing happened, but the different coloured hair was in stripes and bands, as you often see in cats (also in the ant-eater, Fig. 7). This is the explanation given by Dr. E. Bonavia in *Studies in the Evolution of Animals*.

Dr. Bonavia's explanation will not appear so improbable if you study the pangolin (Fig. 6) and the banded ant-eater (Fig. 7).

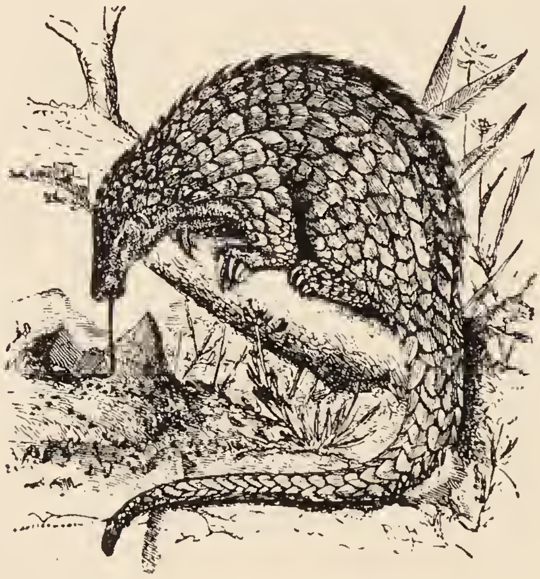

Fig. 6.—White-bellied Pangolin (Manis tricuspis).

This creature, a true ant-eater, has the hair glued together to form overlapping scales. It has not skin-plates like the armadillo, and it has no teeth. Its habit is to live in trees, and it belongs to that group of strange animals called the edentata (the toothless), though some of the group have teeth. The animals in this group are true mammals.

In that equally strange group, the modified mammals (metatheria), we find a good example of the bands of differently coloured hair (Fig. 7).

This division, metatheria, includes the curious pouched mammals of Australia and the neighbouring islands and the opossums of America. For more important reasons this group is one of vast interest, because the ancestors of man seem to have passed through some group of the pouched animals (see Figs. 129–135, in Chapter IV.).

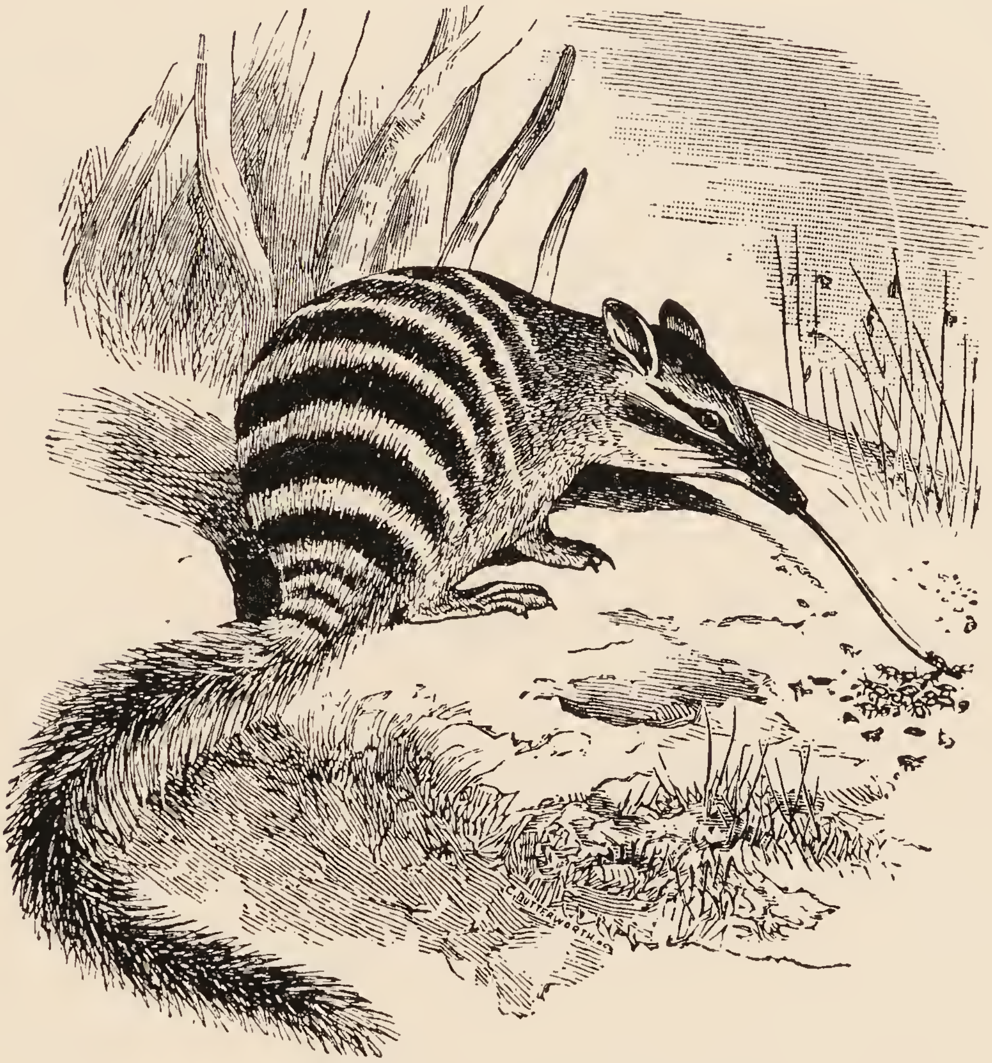

Fig. 7.—Banded Ant-eater (Myrmecobius fasciatus).

LESS KNOWN ANIMALS.

Many, doubtless, find a great difficulty in understanding evolution because they know so little about plants and animals, especially the very small and the very large kinds.

In Fig. 8 we have a very small vegetable moner (phytomoneron); the small round bodies secrete a shapeless, jelly-like mass: in this mass the tiny unnucleated cells (cytodes) increase continually by cleavage. This method of growth by cleavage is common to all plants and animals, especially in their first stages. But who, on looking at these very small bodies, would suppose them to be magnified a thousand times? And if it were possible to realise how small they are, who would suppose that such invisible specks of matter obeyed one universal law of life, and grew by dividing into two?

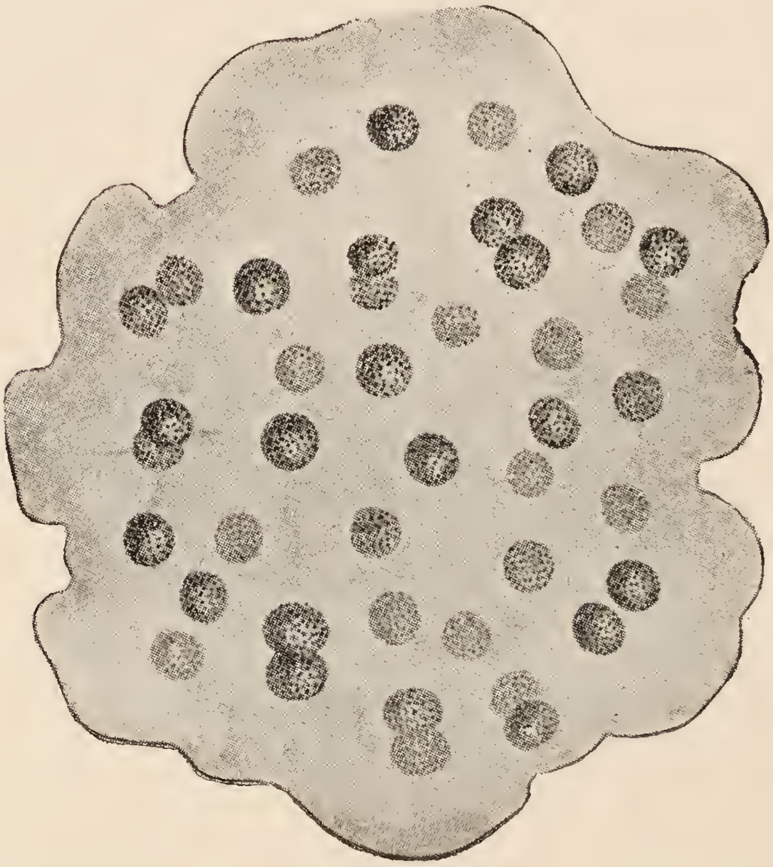

Fig. 8.—Aphanocapsa primordialis (Nägeli), magnified a thousand times.

For further examples of small creatures see Chapter III., Figs. 66–72.

For very large animals it is better to go to some museum and become familiar with their skeletons.

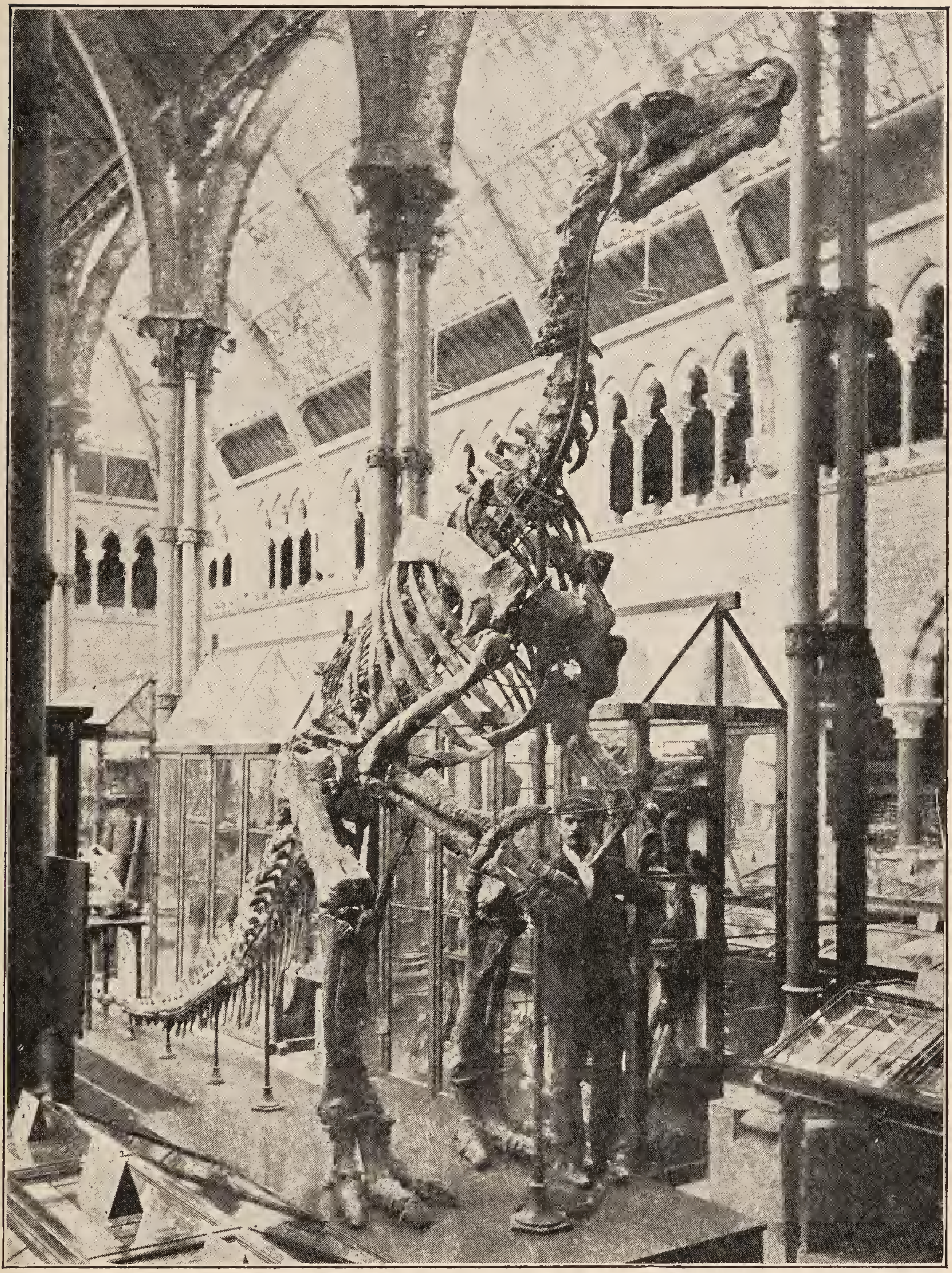

FIG. 9.—Skeleton of Iguanodon.

Fig. 9 shows the well-known iguanodon, with a man standing in front, from which some idea may be formed of its enormous height.

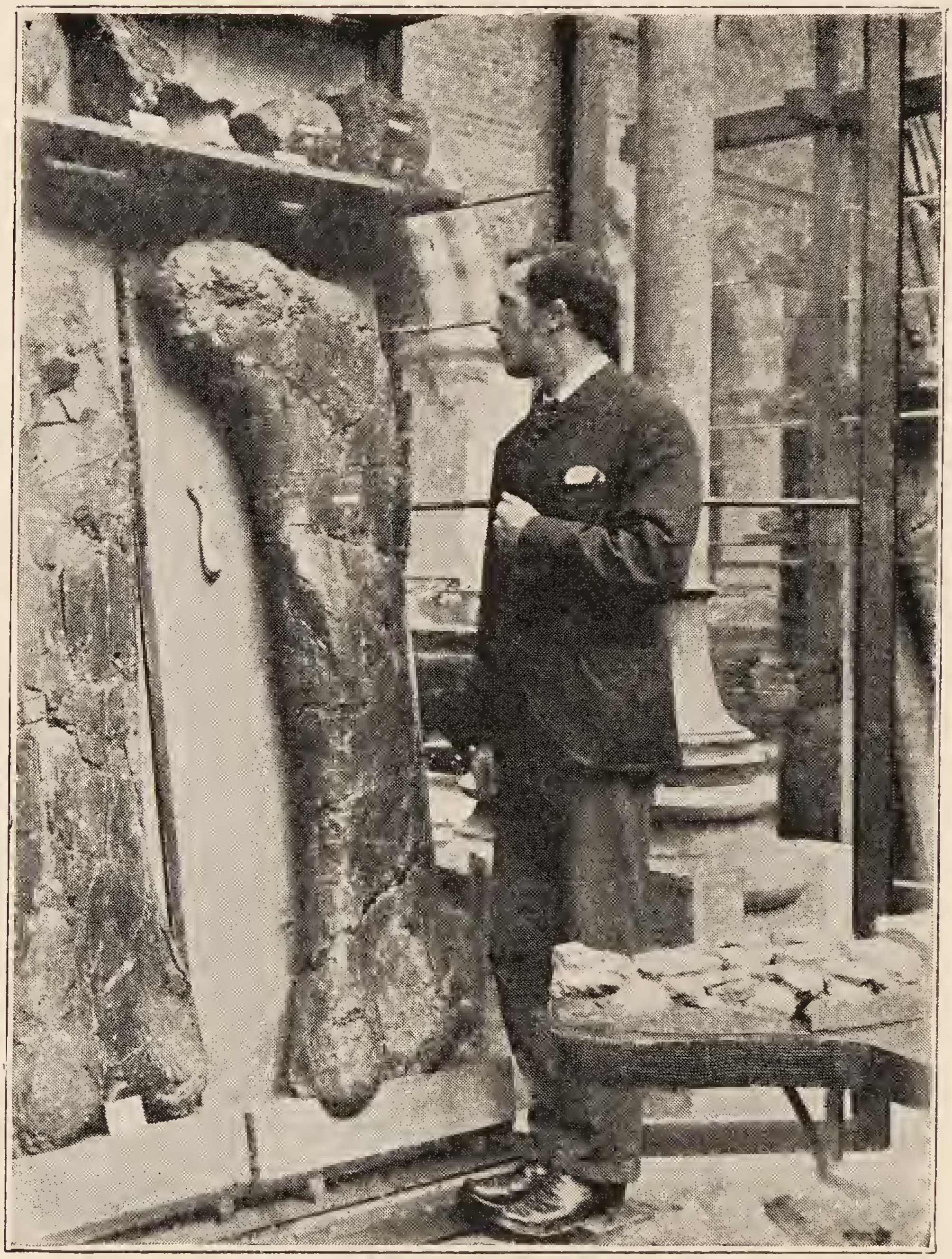

FIG. 10.—Femur of Ceteosaurus.

Fig. 10 shows the femur (the thigh-bone) of the ceteosaurus, with a man standing beside it. There are thigh-bones—of the brontosaurus and atlantosaurus—which are longer.

Fig. 11 shows the iguanodon restored.

Fig. 12 shows the skeleton of the atlantosaurus compared with the height of a man. This is the most gigantic creature yet known; the femur was more than 8 ft. long, the length of its body about 100 ft., and the height 30 ft. or more (Sir Archibald Geikie).

Fig. 13 shows the animal restored, and it is represented as leaning against the Duke of York's Pillar in London, so as to convey some idea of its enormous size. We are told that some of these creatures weighed over twenty tons.

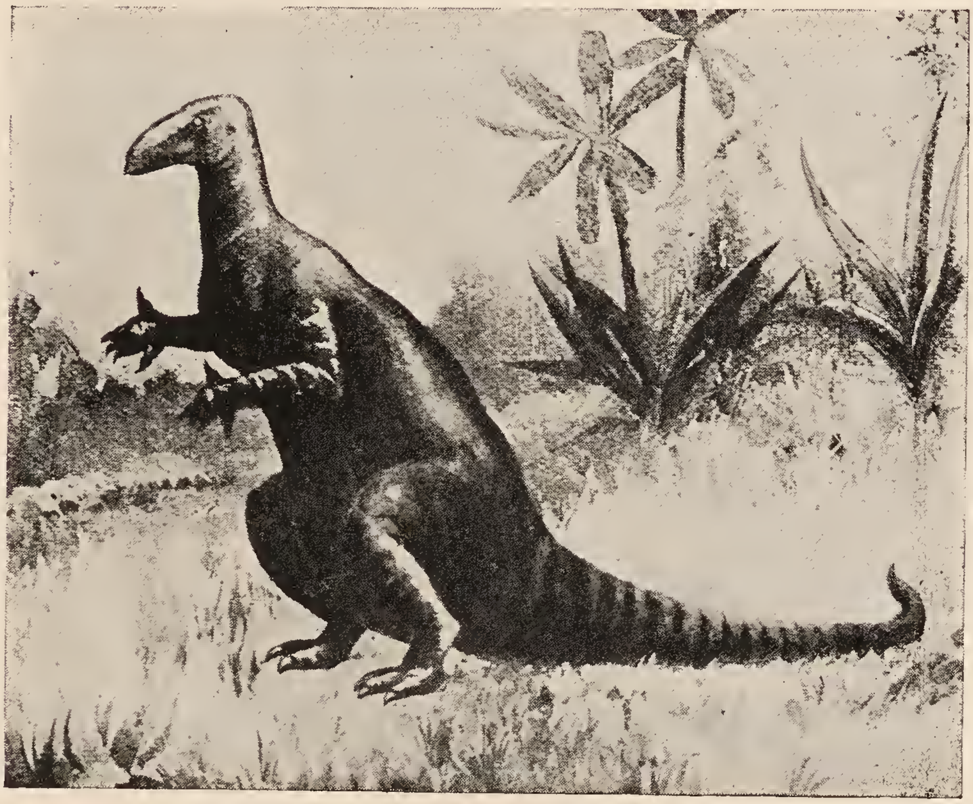

FIG. 11.—Iguanodon, restored.

It has been suggested that the ceteosaurus walked along the sea or river bottom, keeping its head just above water. Specimens of over sixty feet in length have been found.

WORDS.

Both in the *Picture Books* and in my *Easy Outline of Evolution* I have avoided the use of

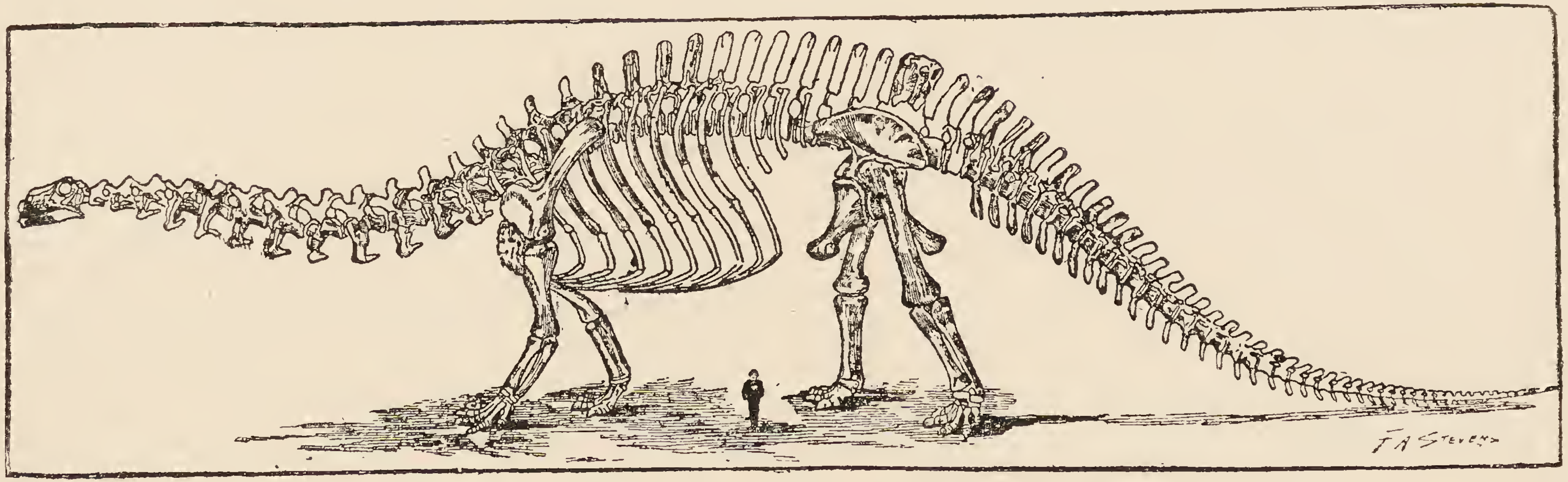

FIG. 12.—Skeleton of Atlantosaurus, and man.

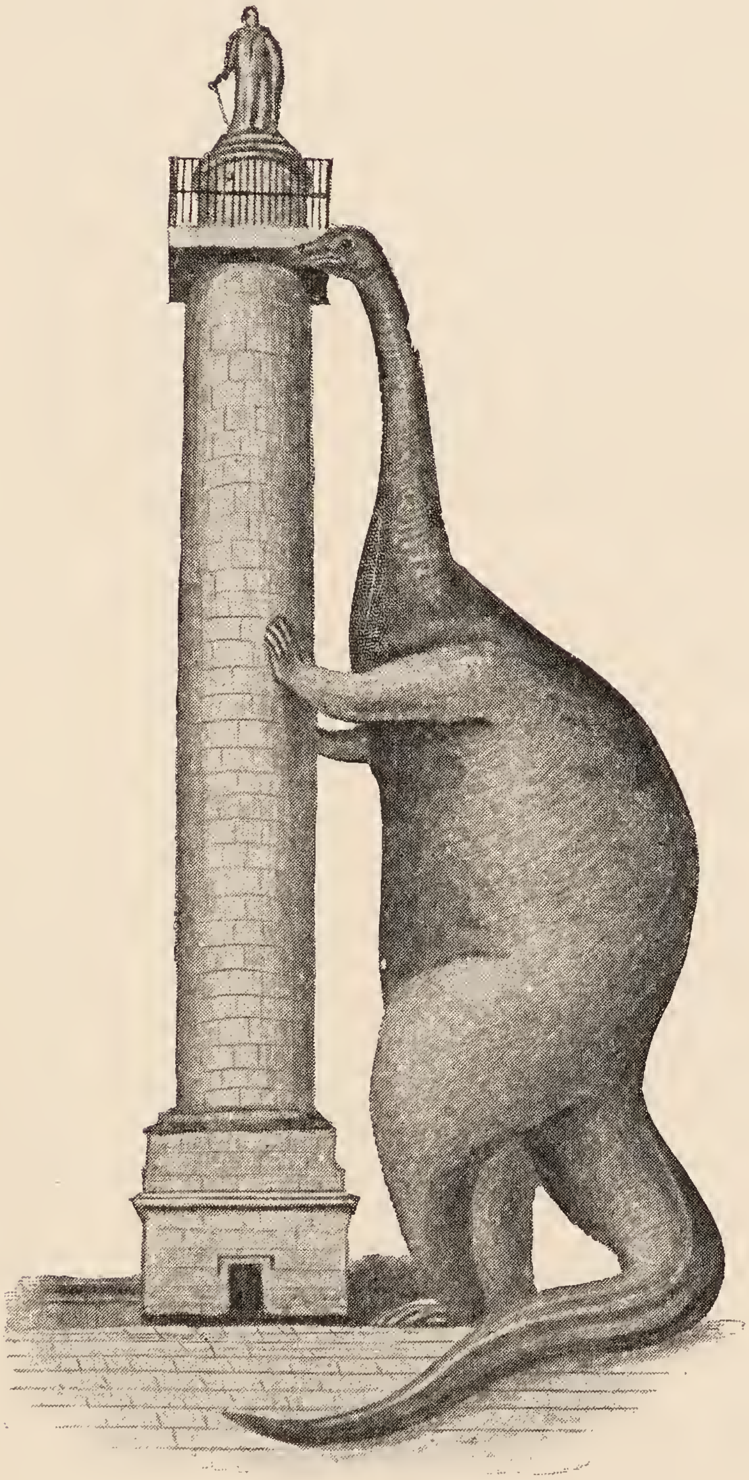

FIG. 13.—Atlantosaurus, restored.

long scientific words as far as possible; when compelled to use them, I have usually explained them.

But there is one set of words which occur so

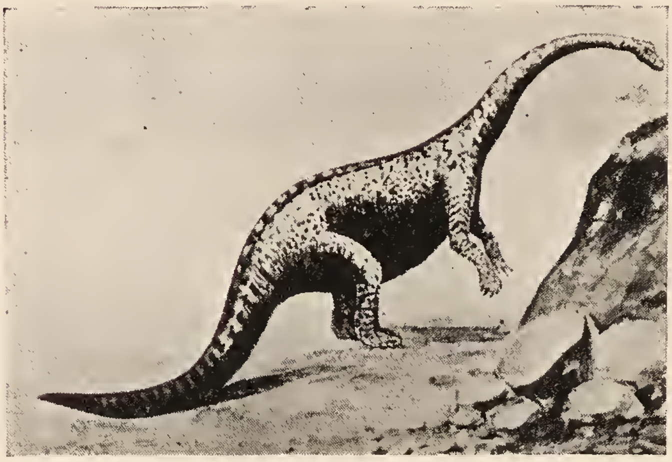

Fig. 14.—Probable appearance of the Ceteosaurus (and of the closely similar Diplodocus and Brontosaurus) in life. (After *Ray Lankester.*)

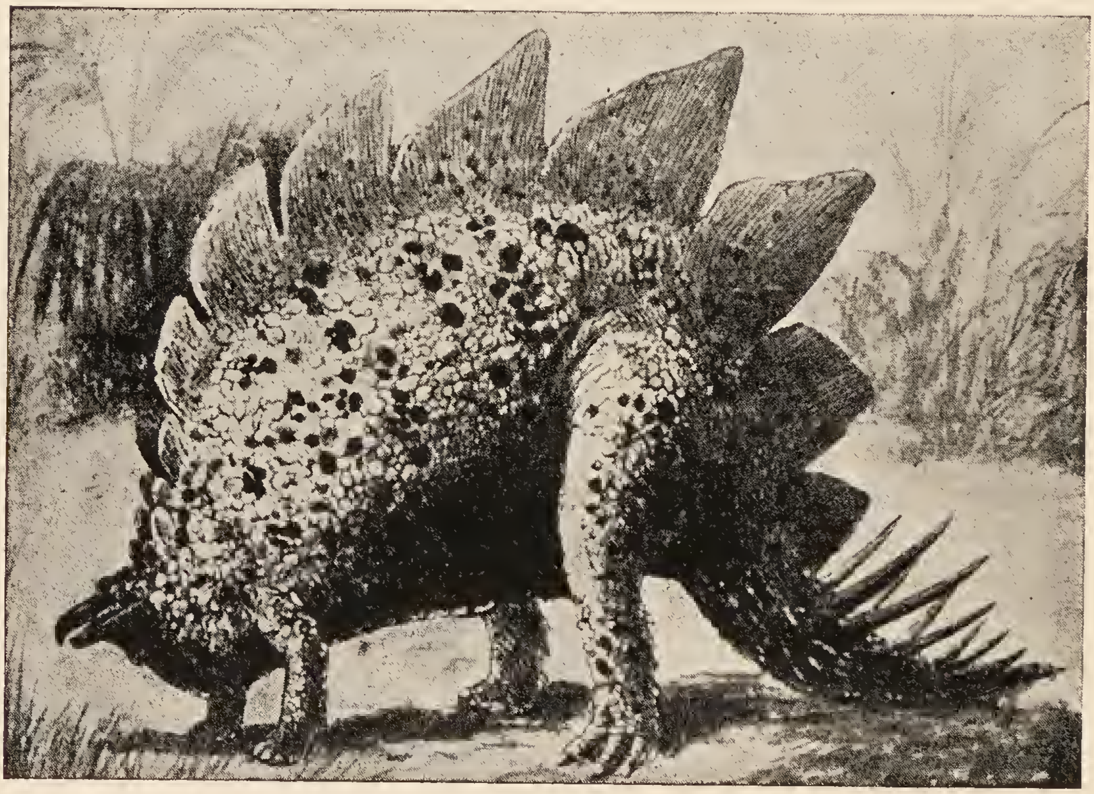

Fig. 15.—Probable appearance in life of the Jurassic Deinosaur, Stegosaurus. The hind leg alone is twice as tall as a well-grown man. (After *Ray Lankester.*)

often, and which are of such importance, that they must be carefully mastered by the serious student, so I give them fully. These words are: Ontogeny, phylogeny, palingenesis, cenogenesis.

In all these words is seen *Gen*.

Gen is the root of the Greek word *gen*nao, to beget; *gen*ea, birth, race, descent; *gen*esis, origin, birth, descent.

To the affix GEN *y* is joined to many words with the meaning birth of, origin of, development of.

Now we can look at the other parts of these words:

On (genitive *ontos*) means being, organism, individual.

Phyle (or *phylon*) means tribe, species, race.

Palin means again, a second time.

Cēno (should be spelt *kaino*) means new, fresh.

So now we see:

Ontogeny = the development of the individual organism, the conception, birth, and growth, or the life-history, of one being.

Phylogeny = the development or life-history of a tribe or species.

If applied to man only, phylogeny means the development of the *race* as a whole from the lowest forms of living things; while ontogeny means the development of the *individual* human being.

Now it has been discovered that each individual, in its growth from a fertilised egg to an adult, repeats to a great extent those forms of life through which the race has passed in all its history. This is what is meant when we read that ontogeny repeats the phylogeny.

This process is called "the fundamental law of biogeny," or the "biogenetic law."

Biogeny is from the Greek word *bios*, life; so biogeny means the origin and development of living things—in fact, the history of the evolution of organisms.

Genetic is from the same root *Gen*, and means pertaining to generation or origin, so that the biogenetic law is the law of the origin and growth of living things.

If each individual, in its ontogeny, passed through every stage of phylogeny, this would be a case of perfect palingenesis, and one could easily read the history of its ancestry.

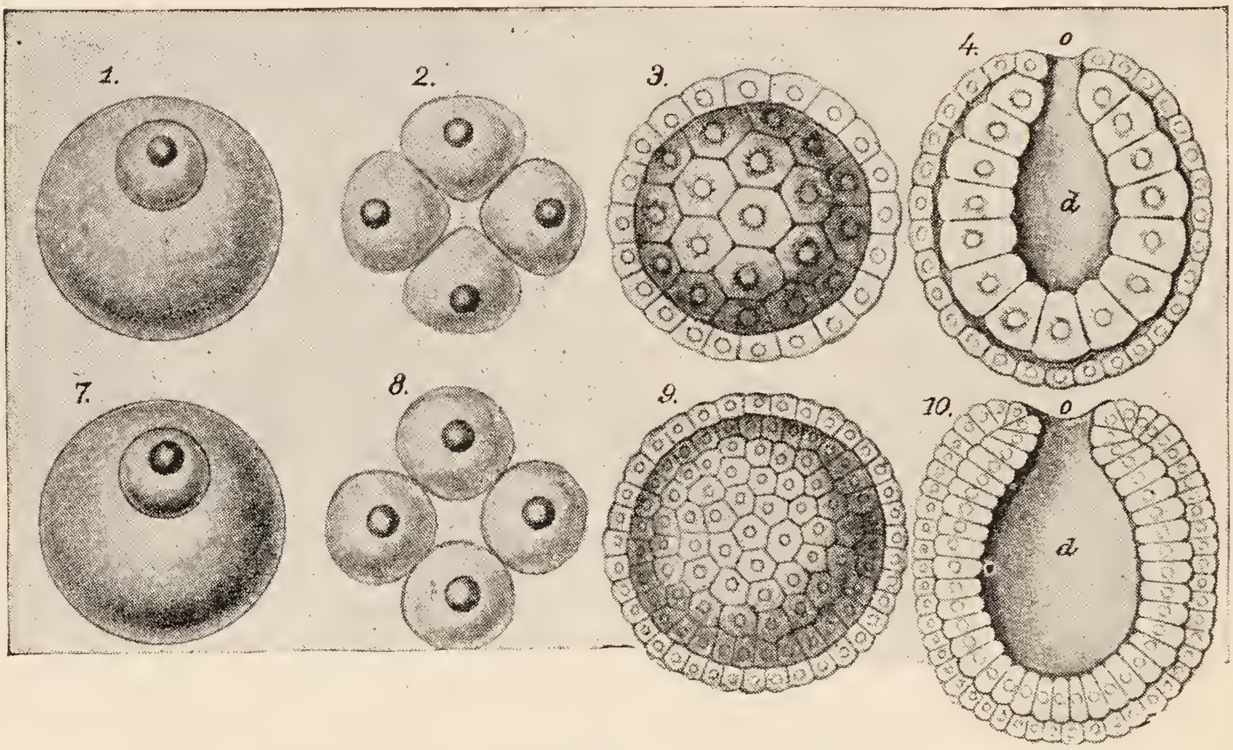

FIG. 16.—A good case of Palingenesis.

Palingenesis means repeated or recapitulated life-history of the race shown in the individual growth, especially before birth.

But it is so many millions of years since the lowest forms of living things appeared on the earth that no one of the higher animals repeats *all* the stages through which its ancestors passed. To express this we say the palingenesis is not complete. It is as if the embryo took short cuts now and then, owing to the enormous periods of history whose millions of years it has to travel in a few weeks.

Further, an embryo may pass through stages of growth which are not all recapitulations of a remote past history. In the later and higher animals the embryonic growth itself has been modified by adaptation to new conditions. The introduction of these new features is called cenogenesis or kainogenesis, new growth.

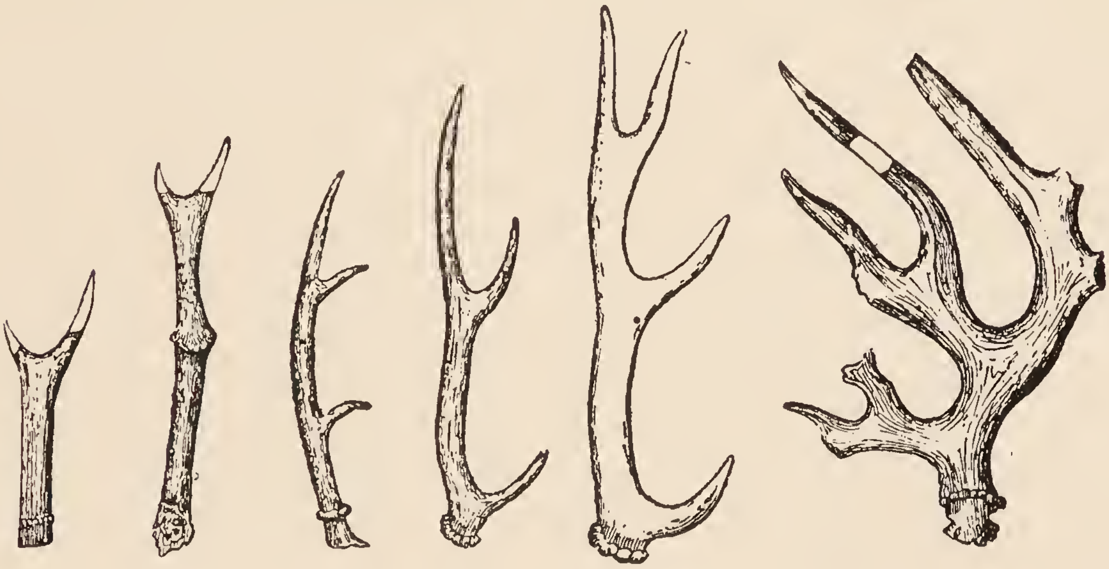

FIG. 17.—Fossil Antlers.

Clearly, the two rows are almost exactly alike in Fig. 16. The top row is an ascidian (Figs. 102, 103, 104, Part I.). The bottom row is an amphioxus (Fig. 105, Part I.).

1 and 7 show the stem-cell (cytula) with its nucleus, and in the nucleus the little nuclear corpuscle or nucleolus.

2 and 8 show the ovum in segmentation. The stem-cell has divided into four equal cells.

3 and 9 show the blastula. The cells formed by the cleavage of the ovum form a spherical vesicle,

filled with fluid, the wall of which consists of a single layer of cells, called the blastoderm.

4 and 10 show the gastrula, formed from the blastula by an infolding at *o*. The wall of the primitive gut (*d*) opens by the primitive mouth at *o*.

Most animals pass through these four stages.

In order to understand more clearly what is meant by phylogeny and ontogeny we may study Figs. 17 and 18.

In Fig. 17 we see the antlers of deer, found as fossils, and representing the development of these horns in the history of the race—phylogeny.

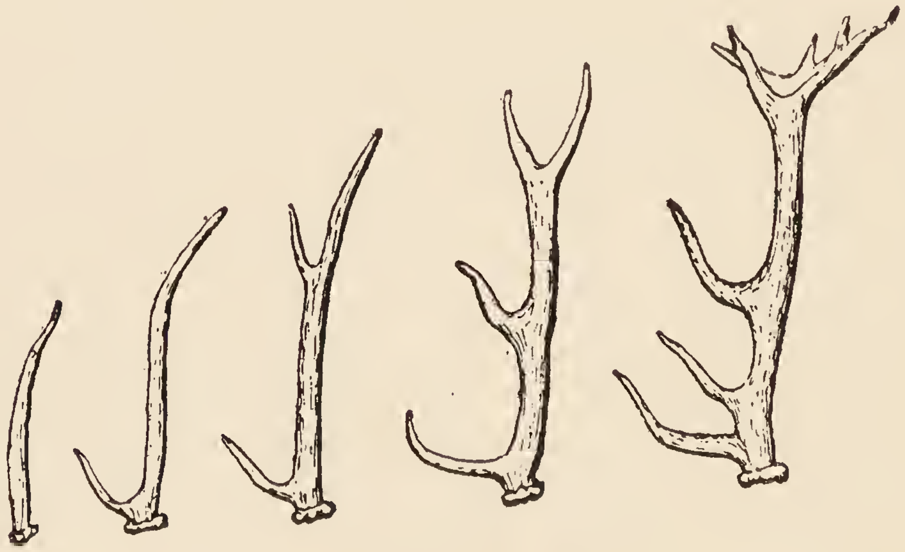

FIG. 18.—Antlers of one Deer.

In Fig. 18 we see the antlers of *one* deer as they grow, year after year, till they become branched—ontogeny. The large group of animals, including sheep, deer, camels, oxen, etc., is called ruminants. The early ruminants were altogether hornless. In the lower Miocene period deer had no horns. In mid-Miocene we meet with two-pronged horns, and the higher we ascend in the beds of rock the more prongs are found, till in the first-bed of Norfolk are found the highly branched horns (No. 6, Fig. 17).

Now, if we turn to Fig. 18, we see the horns as they grow, year by year, in any single stag. This begins with a horn having one simple prong: this earliest form has not yet been found among fossils; but in all the rest we see that the history of the individual shows the history of the race—ontogeny repeats the phylogeny.

A still more striking case of this law is found in the history of fish-tails. I quote Professor Le Conte from Professor Romanes:—

"Among fishes there are two styles of tail-fins. These are the even-lobed, or homocercal (Fig. 19), and the uneven-lobed, or heterocercal (Fig. 20). The one is characteristic of ordinary fishes (teleosts), the other of sharks and some other orders. In structure the difference is even more fundamental than in form. In the former style the backbone stops abruptly in a series of short, enlarged joints, and thence sends off rays to form the tail-fin (Fig. 19); in the latter the backbone runs through the fin to its very point, growing slenderer by degrees, and giving off rays above and below from each joint, but the rays on the lower side are much longer (Fig. 20). This type of fin is, therefore, *vertebrated,* the other *non-vertebrated.* Figs.

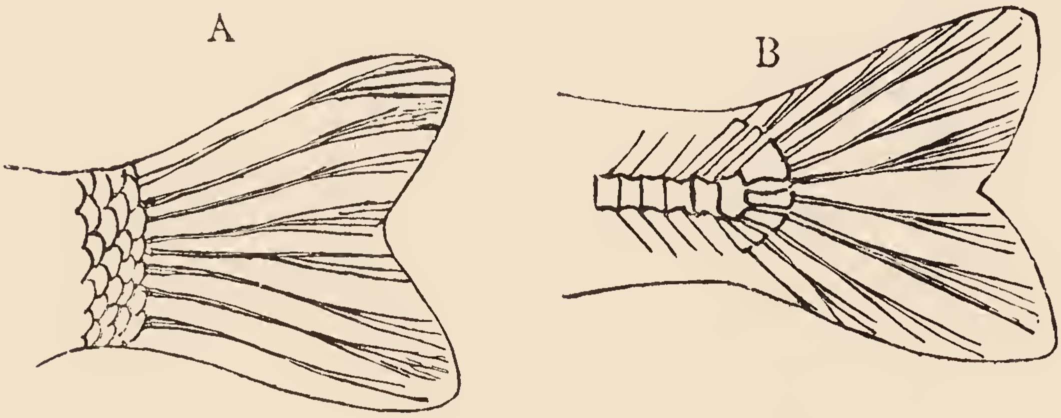

FIG. 19.—Homocercal Tail, showing (A) external form and (B) internal structure.

19 and 20 show these two types in form and structure.

" But there is still another type, found only in the lowest and most generalised forms of fishes. In these the tail-fin is vertebrated and yet symmetrical. This type is shown in Fig. 21.

" Now, in the development of a teleost fish (Fig. 19), as has been shown by Alexander Agassiz, the tail-fin is first like Fig. 21; then becomes heterocercal, like Fig. 20; and finally becomes homocercal, like Fig. 19. Why so? Not because there is any special advantage in this succession of forms; for the changes take place either in the egg or else in very early embryonic states. The answer is found in the fact that *this is the order of change in the phylogenetic series.*

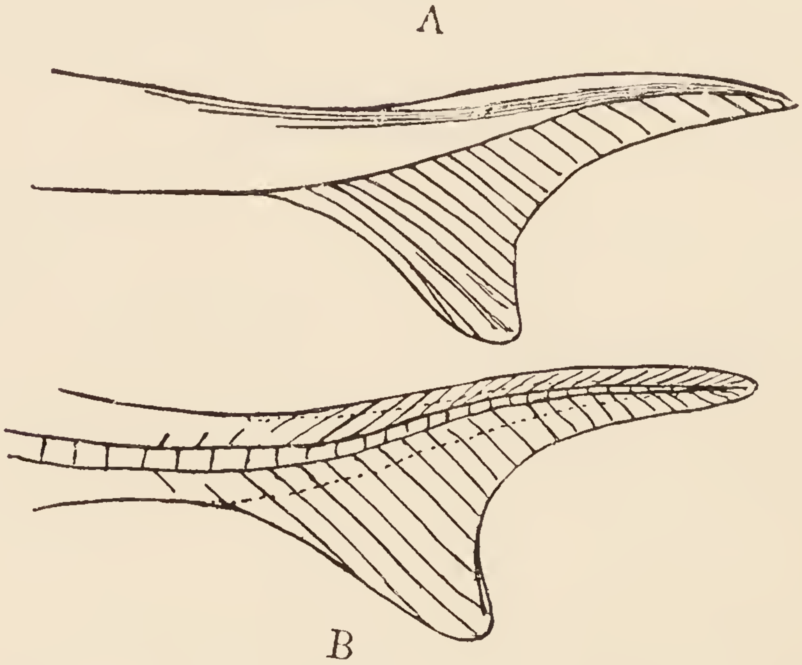

FIG. 20.—Heterocercal Tail, showing A and B as in Fig. 19.

" The earliest fish-tails were like either Fig. 20 or Fig. 21; never like Fig. 19. The earliest of all were almost certainly like Fig. 21; then they became like Fig. 20; and, finally, only much later in geological history (Jurassic or Cretaceous), they became like Fig. 19. This order of change is still retained in the embryonic development of the last introduced and most specialised order of existing fishes. The family history (phylogeny) is repeated in the individual history (ontogeny).

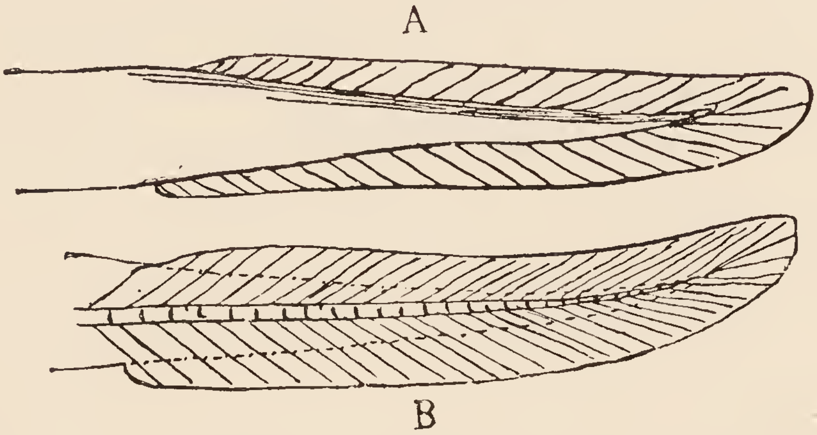

Fig. 21.—Vertebrated but symmetrical Fin (diphycercal), showing A and B as in Fig. 19.

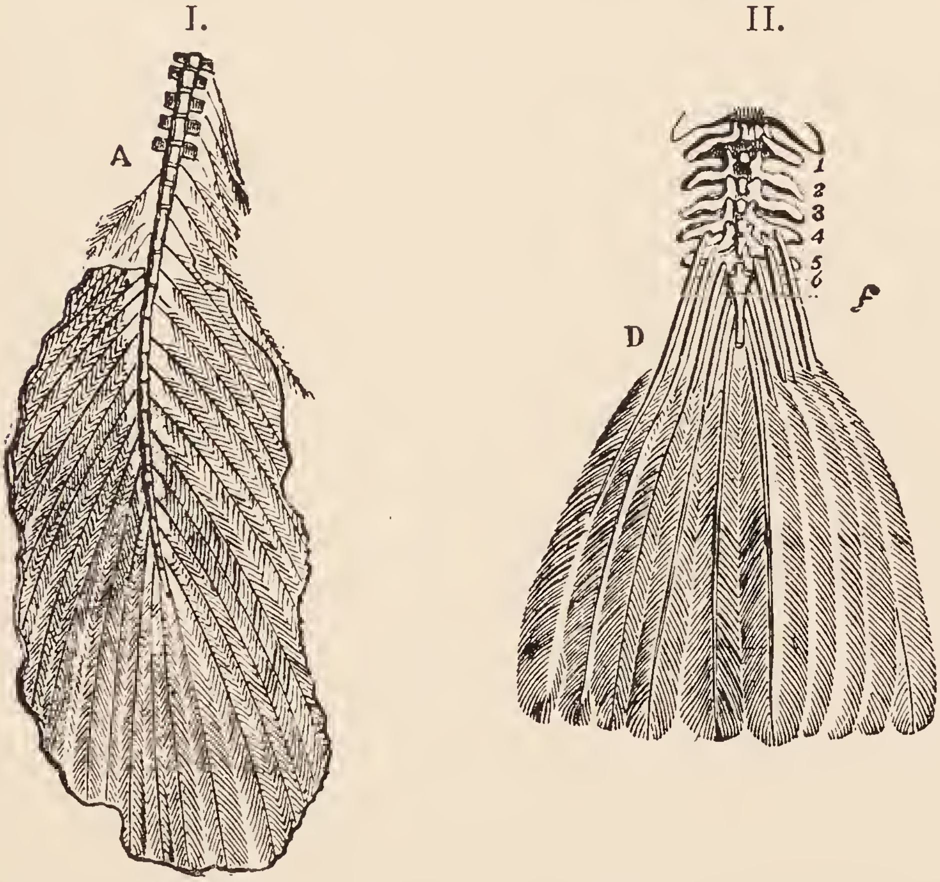

Fig. 22.—I., Tail of Archæopteryx; II., Tail of modern bird. A indicates the origin of simply pointed tail. The numbers in II. indicate the foreshortened, enlarged, and consolidated joints; *f*, terminal segment of the vertebral column; D, shafts of feathers.

"Similar changes have taken place in the form and structure of birds' tails. The earliest known bird—the Jurassic Archæopteryx—had a long reptilian tail of twenty-one joints, each joint bearing a feather on each side, right and left (Fig. 22 A). (See also Fig. 130, Part I.)

"In the typical modern bird, on the contrary, the tail-joints are diminished in number, shortened up, and enlarged, and give out long feathers, fan-like, to form the so-called tail (Fig. 22 D). The Archæopteryx tail is *vertebrated,* the typical bird's *non-vertebrated.* This shortening up did not take place at once, but gradually. The Cretaceous birds, intermediate in time, had tails intermediate in structure. The Hesperornis (Fig. 84, Part I.) had twelve joints. At first—in Jurassic strata—the tail is fully a half of the whole vertebral column. It then gradually shortens up until it becomes the aborted organ of typical modern birds. Now, in embryonic development, the tail of the modern typical bird *passes through all these stages.* At first the tail is nearly one half the whole vertebral column; then, as development goes on, while the rest of the body grows, the growth of the tail stops and thus finally becomes the aborted organ we now find. The ontogeny still passes through the stages of the phylogeny. The same is true of all tailless animals."

DIFFICULTIES.

Many are the difficulties which have been invented since 1859, when Darwin convinced many thoughtful men that evolution was the master-key of the universe.

The same old difficulties, misunderstandings, perversions, misrepresentations, occur each year. They are answered. Again they are answered. Again they appear in the same form, with all the persistence and most of the beauty of spring nettles or autumn thistles.

In vain every teacher and every handbook calls special attention to the fact that evolution does not proceed in a straight line to something better in every single instance; that man has not come from any existing order of ape, monkey, or lemur; that survival of the fittest does not mean survival of the lovely, or noble, or tender, or true; that Natural Selection is not either the *sole* or necessary mode of the operation of force in moulding the world; that Natural Selection does not mean conscious selection or any form of teleology; that relatively persistent species do not mean absolutely *immutable* species.

All these cautions against error have been available to the reading public for nearly half a century; yet, if one meets with an objection to evolution in the House of Lords or the pulpit, it is almost certain to be one of these.

There are even people still to be found in out-of-the-way corners of drawing-rooms who talk of "the missing link," or who say that men have no tails, and so could not be related to the apes. They think apes are barrel-organ monkeys.

"If evolution is true," asks another, "how is it that my hands do not become web-fingered; or, how is it that the monkeys brought over to London do not become more like us?" None of these people would ask, Why does not my half-quarter cousin grow more like me since I lent him some money? Yet a man must admit that his half-quarter cousin and himself had a common set of ancestors once.

TIME.

The vast period of time required to meet the demands of the evolutionist used to be a difficulty;

but I showed in Part I., pp. 50 and 51, that this is no longer a difficulty. There are, however, other points with regard to time that have an intense interest to us, such as the time when man first appeared on the earth, the time when the moon was cast off from the earth, and the time when the earth was cast off from the sun. None of these can yet be *absolutely* settled, but we may get some idea of great periods *relative* to each other.

Professor Lester F. Ward, the great sociologist in America, has worked out this point in a striking way in an article on "Mars and its Lesson."

He says: "The entire history of a planet may be divided into three periods. The *first* period extends from the time when it is thrown off from the parent body to that at which its crust has formed and the temperature of its enveloping waters has fallen to, or somewhat below, the boiling-point.

"The *second* extends from the latter date to that at which either its waters or its atmosphere, or both, have been absorbed, and the planet has been wholly converted into solid matter.

"The *third* embraces the remainder of its existence.

"We can form some idea of the length of the first period from the condition of our solar system. All the outer planets, except the Asteroids and Mars, are still in that period. Of the second period we know much more, because it is the one to which our earth has attained. Mars is also still within it. It is probable that both Venus and Mercury are already close upon this phase.

"As to the third, we are in complete ignorance of its duration.

"We are safe in saying that the second period is much shorter than either of the other two. This period also may be regarded as the life period, for this is the period which embraces all life. At present we are chiefly concerned with the length of this period. Three classes of scientific men have discussed this question—viz., astronomers, physicists, and geologists. They have, of course, differed widely, but there has been a tendency towards substantial agreement. While most estimates make it at least 100 million years, there are more conservative ones, even by geologists. Professor Haeckel, adopting the figure last mentioned, has proposed to call this life-history of the earth its cosmic day, consisting of twenty-four hours, and he proceeds to reduce the several geological formations to this scale, and to express them in hours, minutes, and seconds. The results are very striking. It seems to me best to use a somewhat lower estimate of the time, and 72 million years seems to be a fair mean.

"The following table shows the results :—

Geologic Periods.		Years.	Hours.	Mins.	Secs.
Pre-Cambrian or Eozoic	Archean	18,000,000	6		
	Algonkian	18,000,000	6		
Paleozoic	Cambrian	6,000,000	2		
	Silurian	6,000,000	2		
	Devonian	6,000,000	2		
	Carboniferous	6,000,000	2		
Mesozoic	Triassic	3,000,000	1		
	Jurassic	3,000,000	1		
	Cretaceous	3,000,000	1		
Tertiary		2,675,000		53	30
Quaternary		300,000		6	
Historic period		25,000			30
Total age of the earth		72,000,000	24		
Age of written language		6,000			

"The extraordinary fact comes out that the human race, which probably had its origin in the Quaternary period, or possibly in late Tertiary time, has only existed between six and seven minutes of the cosmic day, while the extreme maximum estimate of the historic period does not exceed thirty seconds, and that of its recorded annals is little more than seven seconds."

This striking result will be better seen in the form of a dial (Fig. 23):—

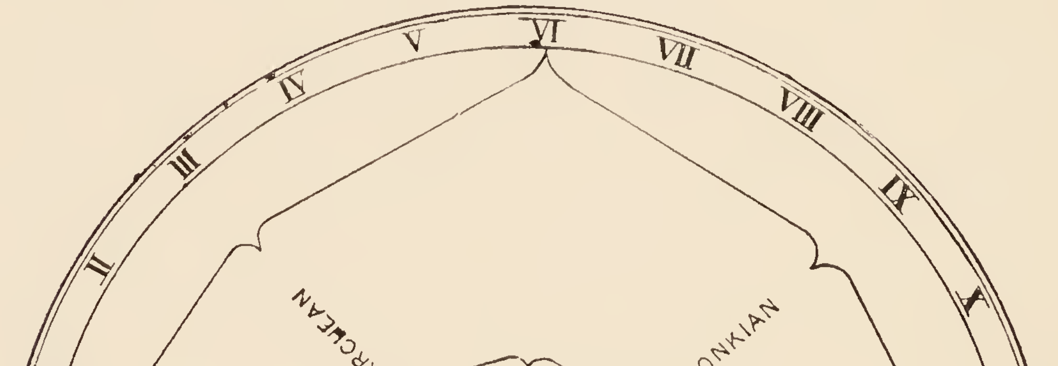
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
XVI
XVII
XVIII
XIX
XX
XXI
XXII
XXIII
XXIV
I
II
III
IV
V
ARCHEAN
ARCHEOZOIC
ALGONKIAN
HISTORIC
QUATERNARY
PSYCHOZOIC
CENOZOIC
TERTIARY
CRETACEOUS
MESOZOIC
JURASSIC
TRIASSIC
CARBONIFEROUS
DEVONIAN
PALEOZOIC
SILURIAN
CAMBRIAN

FIG. 23.—Dial of the Cosmic Day, or life-history of the earth.

To understand the geological periods, see Part I., Fig. 62; also Fig. 97.

It should further be borne in mind that Professor

Ward has taken a very low estimate of the time during which life has been on the earth ; but this does not disturb the relative calculations of the different periods.

Chapter II.

COMPARATIVE ANATOMY

Some few vain people are still hurt when they learn for the first time how closely their bodies resemble the bodies of the lower animals. Some are even so childish as to be offended because we can prove that they have descended from a long line of animal ancestors. Some ignorant people refuse to hear what can be said in explanation of man's evolution from animals, because they have already made up their minds that they will never accept such an explanation.

All these classes, however, are growing beautifully less year by year, and we may venture to compare man with other animals, in a simple way; and instead of feeling humiliated at our kinship we shall, I hope, be struck by the mystery and beauty of a world in which all living things form one vast family.

In Part I., Figs. 10–13, we learnt some lessons from the horse, and we might begin our comparative anatomy by learning a few more lessons from this very wonderful animal.

Of course, it is well known that man and the horse have both come from the same early group of animals. If we were to trace their ancestors far enough back, we should see this. Man and horse, together with the rest of mammals, must have come through the reptiles known as mammal-shaped (theromorpha, Figs. 126, 127). It is, therefore, interesting to take the skeleton of the horse and compare it, bone by bone, with that of man. After a careful examination, the first striking thing is that both man and horse have almost exactly the same bones. This skeleton must, therefore, so far, have been acquired *before* their ancestors parted, to go on separate lines of evolution.

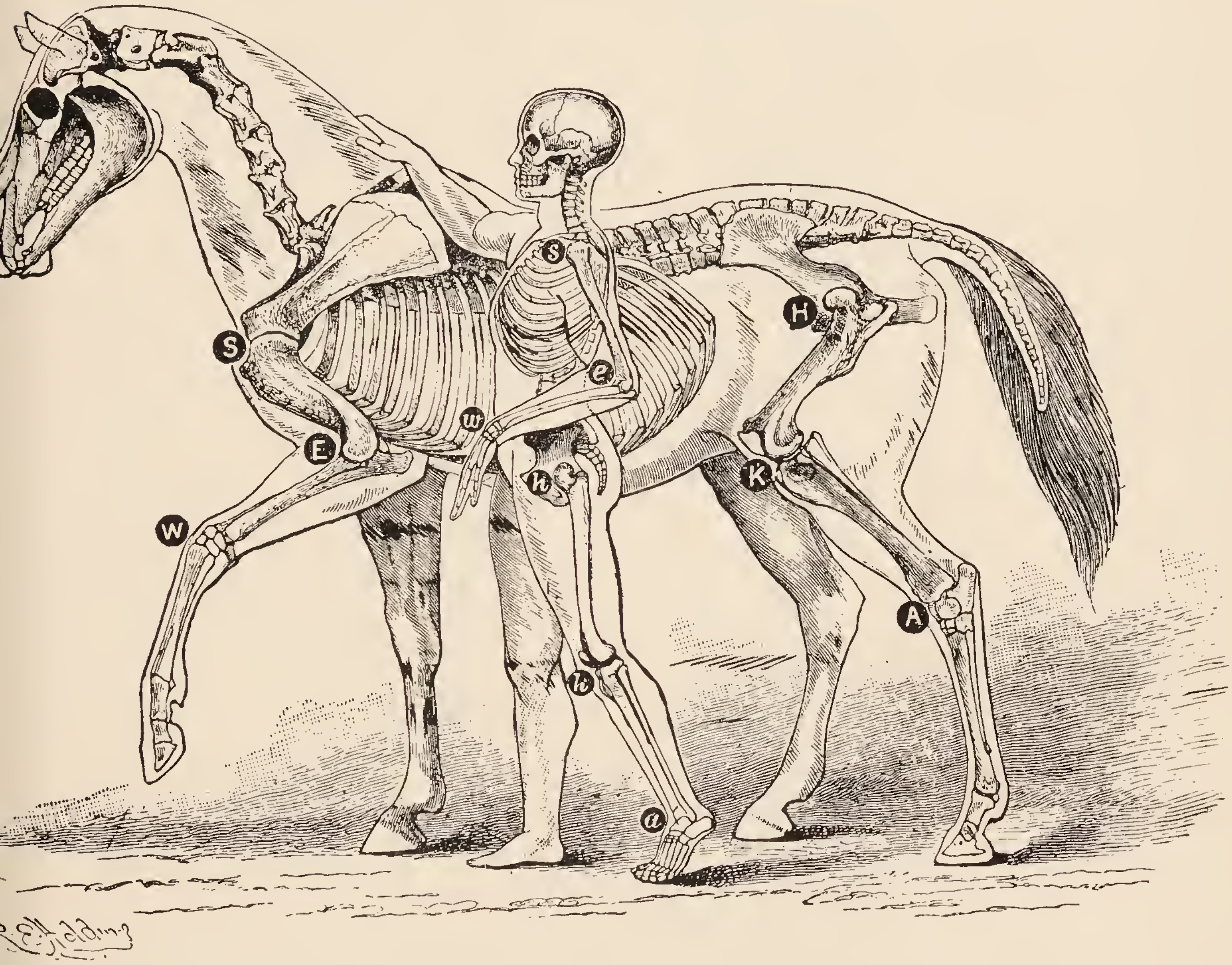

FIG. 24.—Comparative view of the Skeleton of Man and Horse. S, shoulder-joint; E, elbow-joint; W, wrist-joint (knee in the horse); H, hip-joint; K, knee-joint (stifle); A, ankle-joint (hock). (After *Flower.*)

We should see the similarity of the skeletons far better if man and horse walked in the same way. Some animals walk on their feet, and some on their toes. The former are called plantigrade, the latter digitigrade. Man is plantigrade, and the horse digitigrade.

The horse belongs to the large group of hoofed animals, the ungulates. This group is divided according to the toes; one class is even-toed, Artiodactyla; the other class odd-toed, Perissodactyla (from the Greek *artios*, even in number, and *perissos*, uneven, combined with *daktylos*, finger or toe).

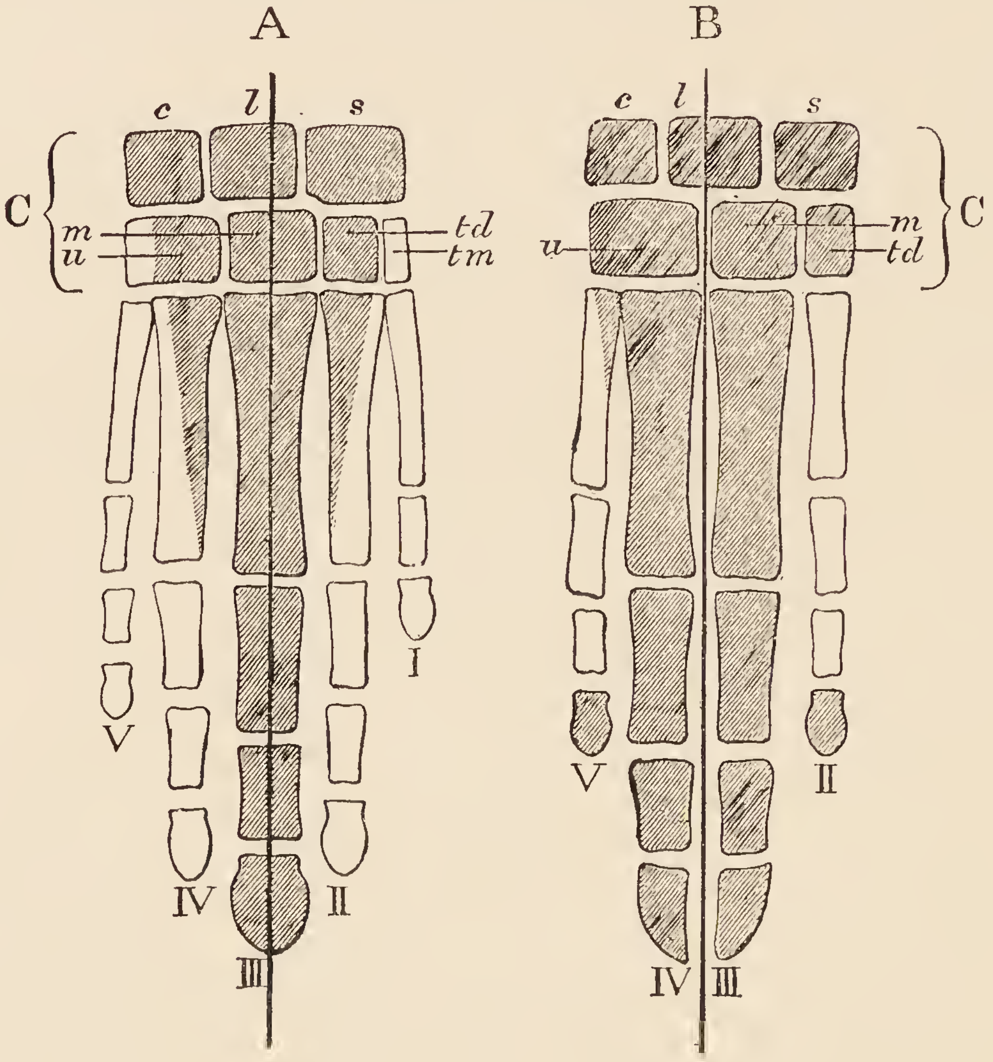

FIG. 25.—Diagrammatic representation of the Bones of the Foot. A, diagrammatic representation of the bones of the right fore-foot of an odd-toed or perissodactyle animal; B, of an even-toed or artiodactyle animal; C, the carpus or wrist, consisting of two rows of bones, the upper being *c*, cuneiform; *l*, lunar; and *s*, scaphoid: the lower, *u*, unciform; *m*, magnum; *td*, trapezoid; and *tm*, trapezium. The long bones in contact with the last constitute the metacarpus; the remaining bones are the phalanges. The digits or toes are numbered in order from the inner to the outer side of the foot. The shaded parts of A are those that are present in the horse; in B, those that are present in the ox. (After *Flower.*)

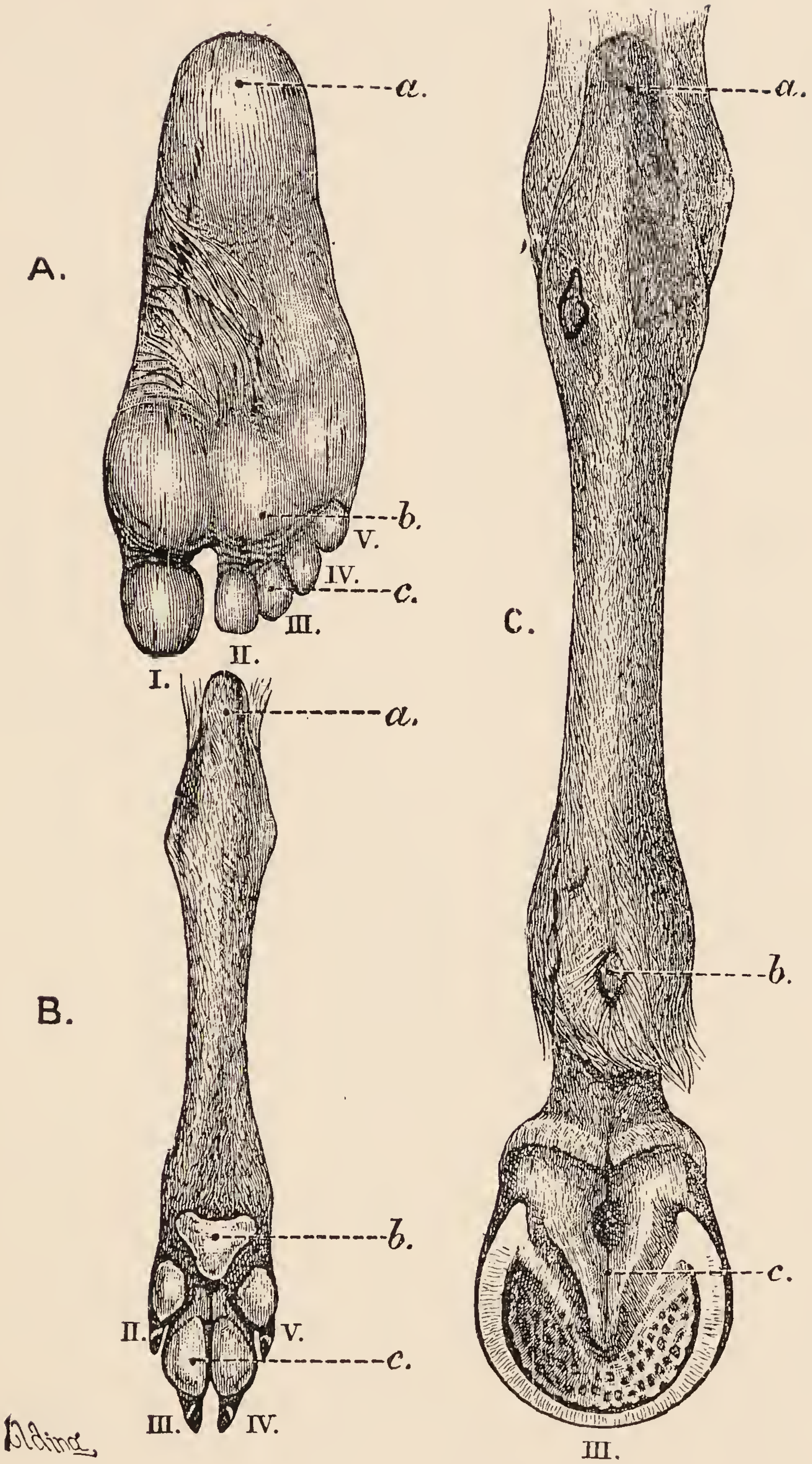
A.
a.
b.
V.
IV.
c.
III.
II.
I.
B.
a.
b.
II.
V.
c.
III.
IV.
C.
a.
b.
c.
III.

FIG. 26.—Plantar Surface of the Foot of—A, man; B, dog; C, horse. The letters *a*, *b*, and *c* indicate the corresponding points of the three. (After *Flower*.)

The artiodactyles (even-toed) include the pig, deer, ox, sheep, goat, camel, giraffe, hippopotamus. Their feet are formed on the plan of B in Fig. 25.

The perissodactyles (odd-toed) include the horse, tapir, rhinoceros, elephant. Their feet are formed on the plan of A in Fig. 25.

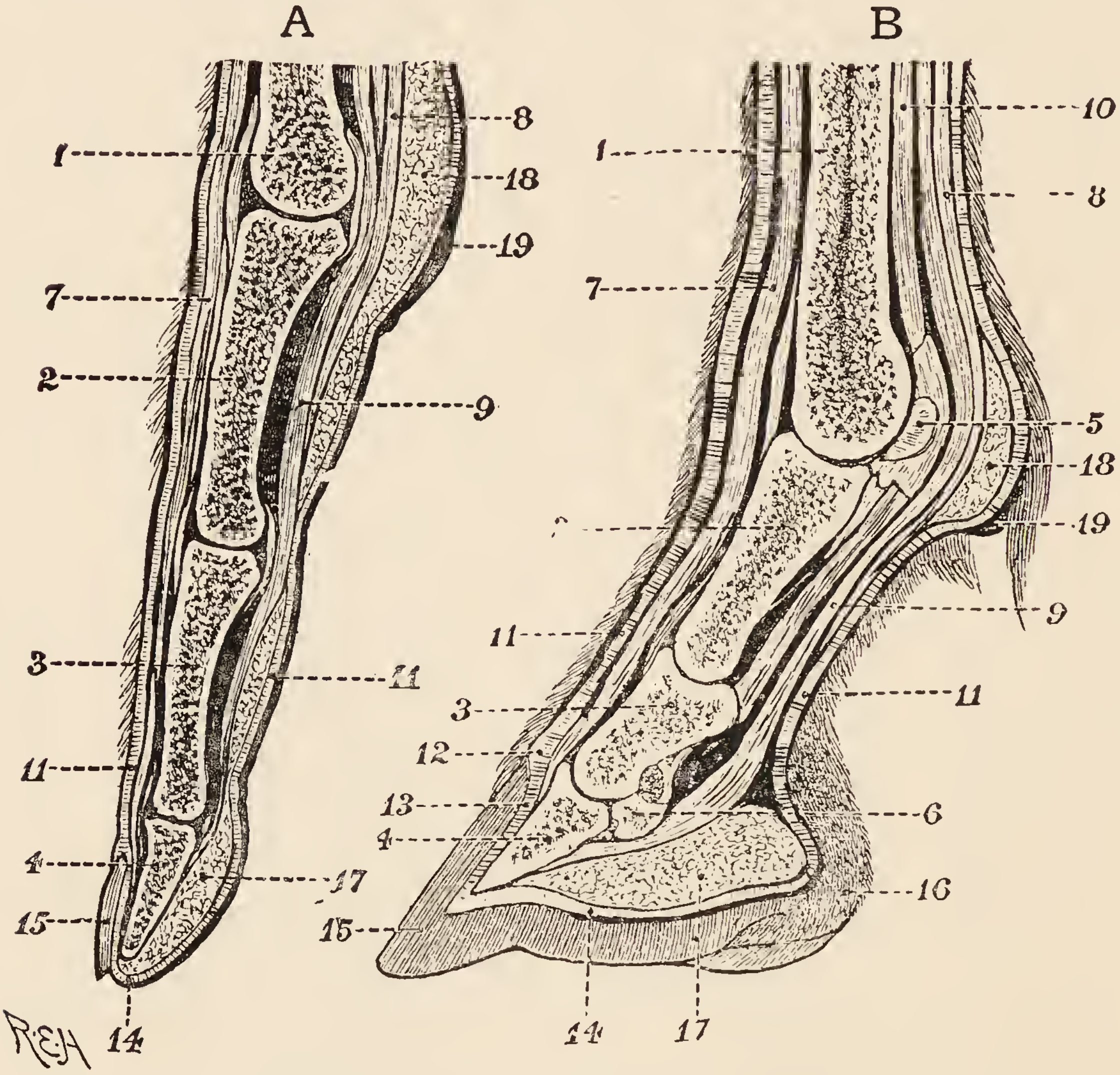

FIG. 27.—A, section of the finger of man; B, section of the foot of horse. In both A and B—*1*, metacarpal bone; *2*, first phalanx; *3*, second phalanx; *4*, third or ungual phalanx. In A—*7*, tendon of extensor muscle; *8*, tendon of superficial flexor; *9*, tendon of deep flexor; *11* and *14*, derm or true skin; *15*, nail; *17*, fibro-fatty cushion of end of finger; *18*, ditto of palm behind metacarpo-phalangeal joint; *19*, thickened skin covering of same. In B—*5*, one of the upper sesamoid bones; *6*, lower sesamoid; *7*, *8*, and *9*, same as in A; *10*, short flexor of fetlock; *11*, derm or true skin; *12*, coronary cushion; *13*, laminal; *14*, villous portion of the hoof matrix; *15*, hoof; *16*, the heel; *17*, plantar cushion; *18*, fibro-fatty cushion of the fetlock; *19*, bare patch with thickened skin covering or "spur." (After *Flower*.) The corresponding parts of A and B have the same numbers.

This plan of the feet should be most carefully studied.

In Fig. 26 A shows the human foot, B and C show what would be the foot used by the dog and the horse if they walked as man does, instead of using only their toes. It is very interesting to compare these three feet, and especially to note *b* in the horse. This is called the ergot in the case of the horse ; it is usually concealed in the hair, is useless, and is a relic of the pad marked *b* in B.

"It remains as an eloquent testimony to the unity of the horse's structure with that of other mammals, and its probable descent from a more generalised form."

Some are filled with laughter when it is said that a horse walks on *one* digit (*i.e.*, one finger or toe) ; but a little examination of A and B in Fig. 27 should prove without doubt that a horse's "foot" is only a finger with an enlarged nail, the hoof.

Fig. 28 teaches us some important lessons, not only about these two skulls, but about all skulls, for it clearly shows how two skulls, widely different in appearance, may contain all the important parts in common. It shows that the great difference in the human skull is due to the large increase in brain development. This figure should help us, also, to understand something of the cause of the difference between the skulls of man and the higher apes.

We may now pass on to comparisons with animals more nearly related to us than the horse.

The numbers and letters on those hands, Fig. 29, always correspond with the same parts. The group of small bones at the top of each form the wrist, and are called the carpus; the long bones, numbered I., II., III., IV., V., form the back of the hand ; after these come the three joints of the thumb and fingers.

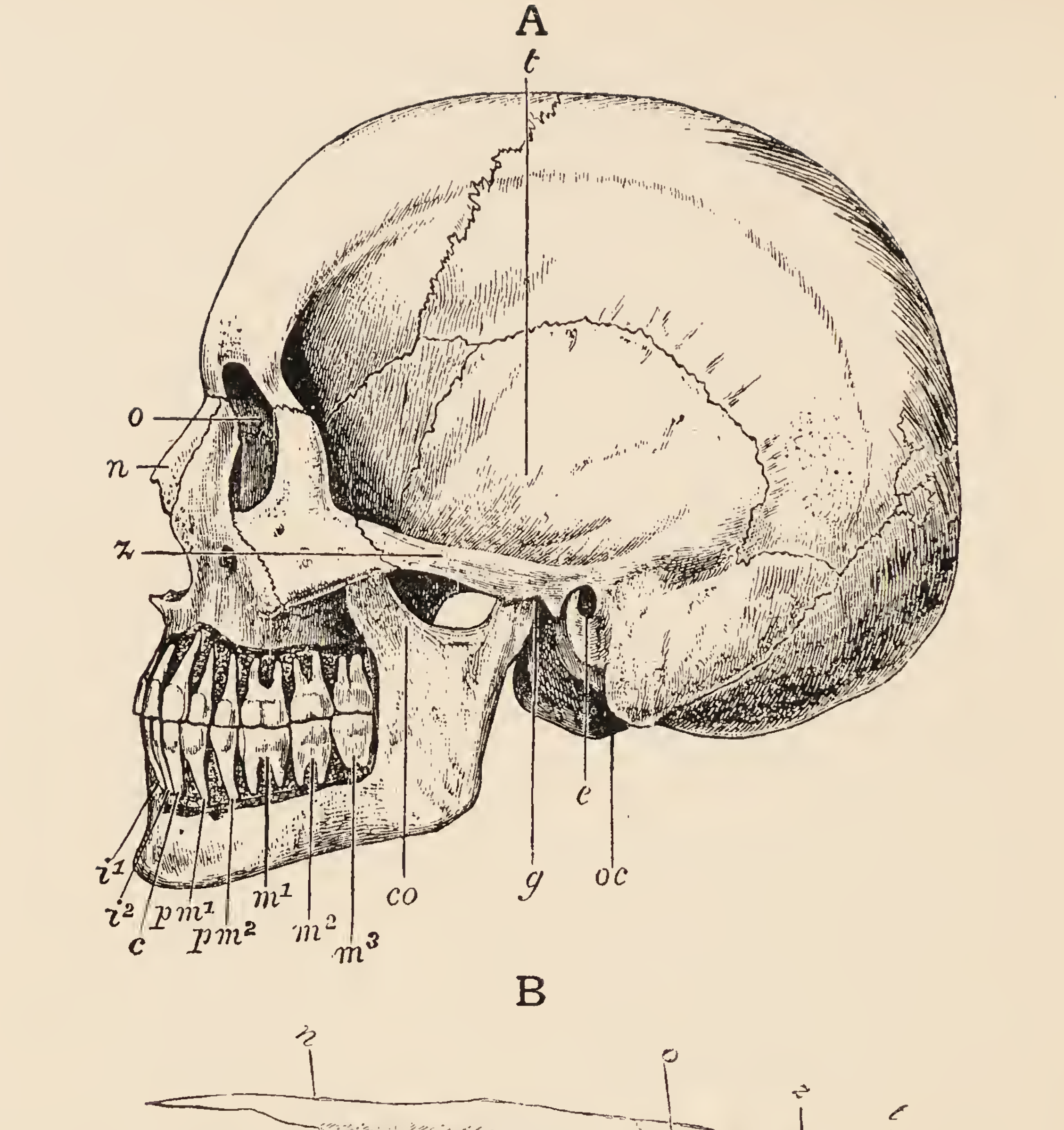
A
t
o
n
z
i^1
i^2
c
pm^1
pm^2
m^1
m^2
m^3
co
g
e
oc
B
n
o
z
t
i 1
i 2
i 3
c
pm 1
pm 2
pm 3
pm 4
m 1
m 2
m 3
g
em.
oc.

FIG. 28.—A, skull of man; B, skull of horse. Side view with the bone removed so as to show the whole of the teeth. The same letters refer to the same parts in both. *n,* nasal bone; *o,* eye; *z,* zygomatic arch; *t,* temporal fossa; *oc,* occipital condyle; *e* or *em,* external opening of ear; *g,* glenoid fossa for articulation of the lower jaw. Teeth—*i,* incisors; *c,* canine; *pm,* premolar; *m,* molar. (After *Flower.*)

To look at them and count the bones is to be convinced that they are identical. There is the same number of bones in each, and they furnish strong evidence that all the animals to which they belong should be placed in one group.

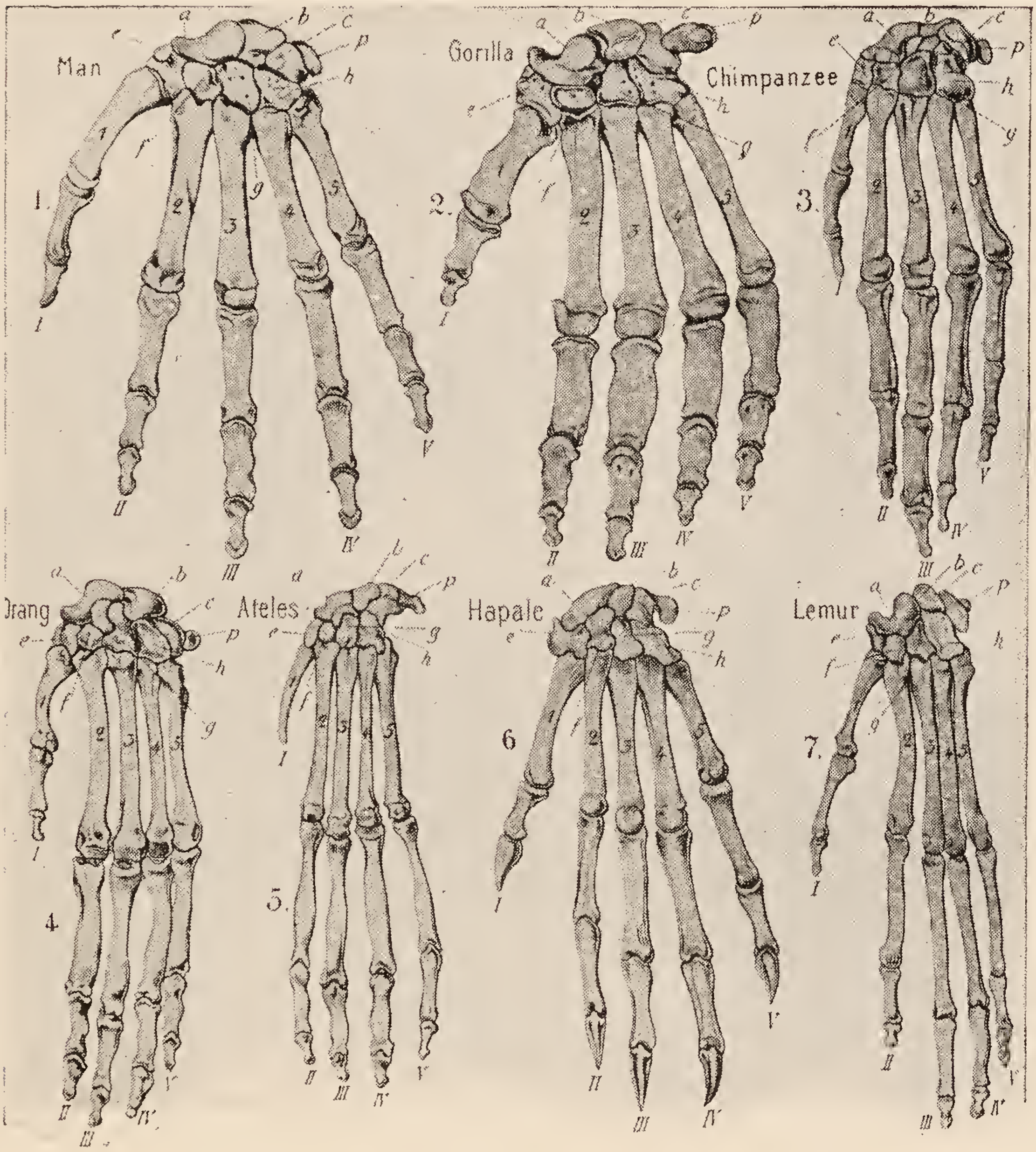
Man
1.
Gorilla
2.
Chimpanzee
3.
Orang
4.
Ateles
5.
Hapale
6
Lemur
7.
a
b
c
p
h
g
e
f
1
2
3
4
5
I
II
III
IV
V

FIG. 29.—Hands.

The numbers and letters in the feet of Fig. 30 always correspond with the same parts.

The most striking thing about all these feet is their great difference from the hands. The mass of bones at the top of each is the ankle-joint (the tarsus), and corresponds, in relationship, with the bones at the wrist-joint ; but in the wrist there are eight bones, and in the ankle seven. So no one need mistake a hand for a foot. Further, observe the very large size of the bones *ab* and *c* ; these form the heel, and there is nothing corresponding to them in the wrist. This point is of

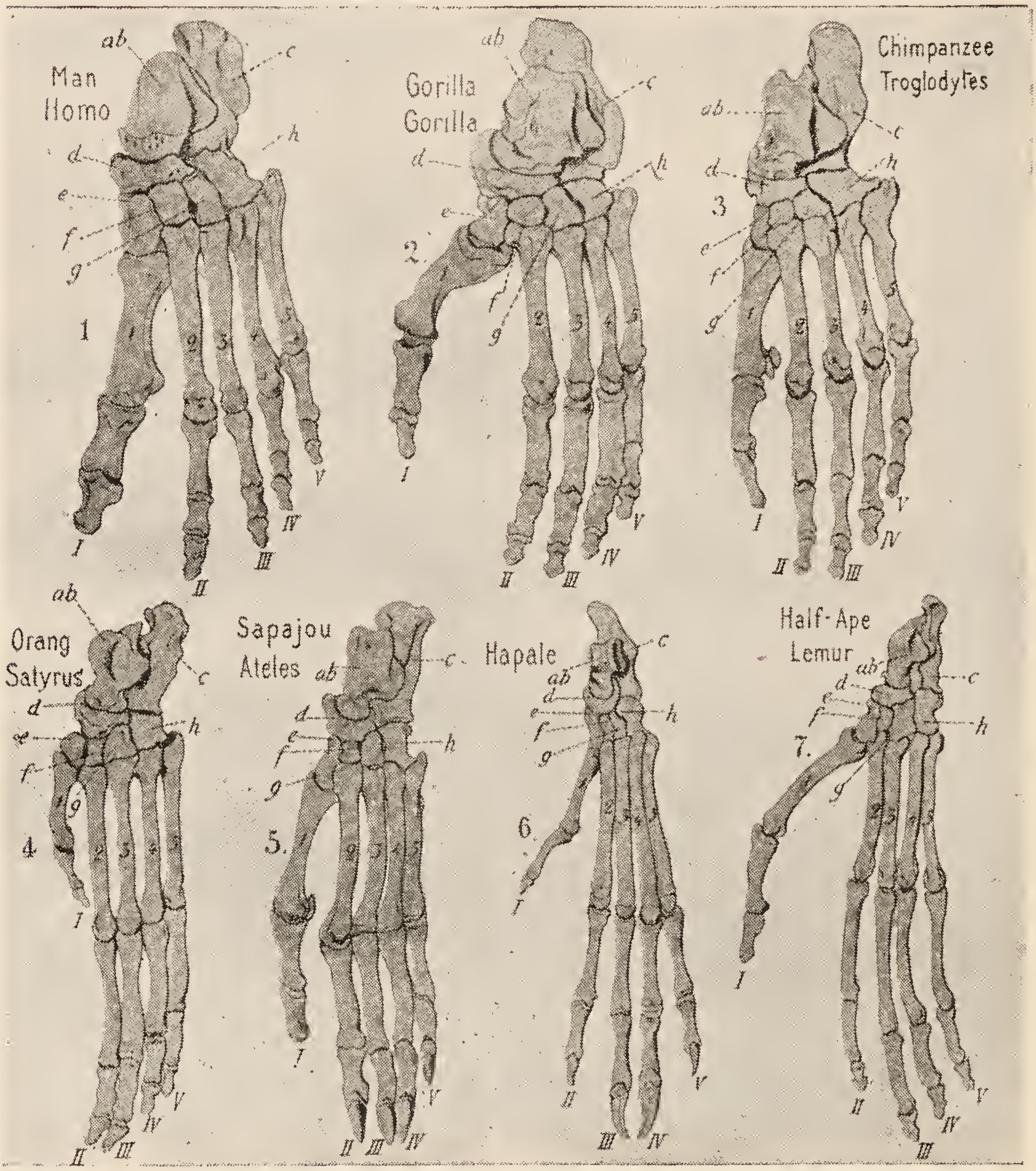
Man
Homo
1
Gorilla
Gorilla
2
Chimpanzee
Troglodytes
3
Orang
Satyrus
4
Sapajou
Ateles
5.
Hapale
6
Half-Ape
Lemur
7.
ab
c
d
e
f
g
h
I
II
III
IV
V

FIG. 30.—Feet.

importance because in one of the *old* divisions of the higher animals the apes were classified as quadrumana (four-handed), and men as bimana (two-handed). Some people still use these obsolete terms, but you see they are not true. If man has two hands and two feet, so have the apes.

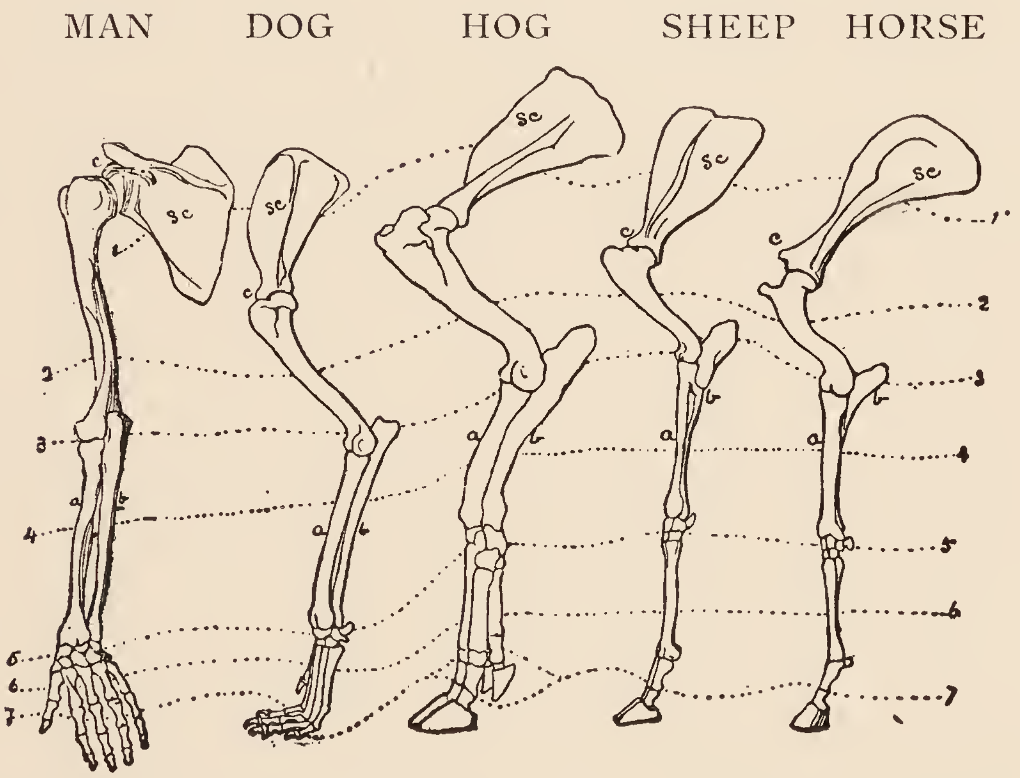

FIG. 31.—A series of Fore Limbs. *Sc,* shoulder-blade; *c,* coracoid process; *a, b,* bones of fore-arm; line *3* passes through the elbow-joint; *5,* through the wrist; *6,* through the bones of the hand; *7,* through bones of the fingers.

The most striking difference is seen in the big toe. In man it lies almost parallel with the other toes; but in the gorilla it is bowed out, so that it is opposable—*i.e.*, it can be pressed against the adjoining toe for grasping. (This arrangement is found in the human embryo, and may still be seen in a very young child after birth—Figs. 89, 90.) It was

[illegible]

this use of the toe in grasping which caused some to think that the animal had four hands.

In reality men and birds are four-footed, for the arm of man and the wing of bats and birds have the same typical skeleton as the fore leg of the animals which are distinctly four-footed (quadrupeds).

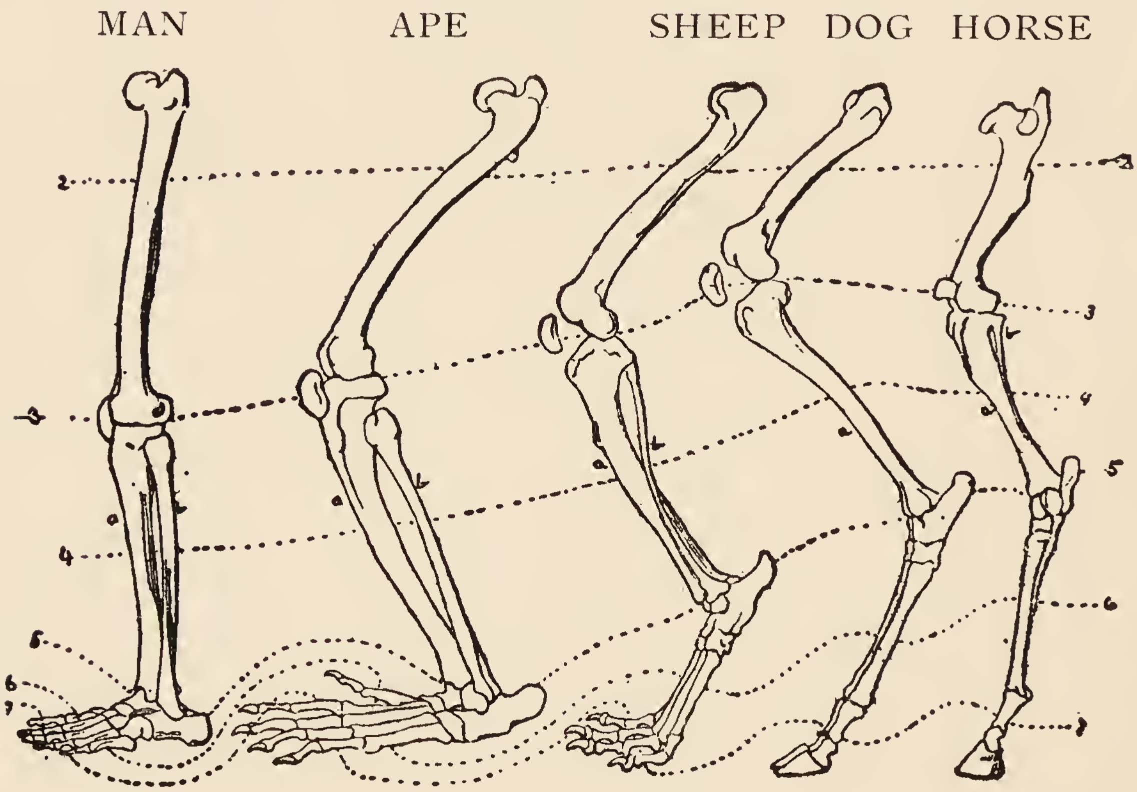

FIG. 32.—A Series of Hind Limbs. The top is the hip-joint; line *2* passes through the femur or thigh-bone; *3*, through the knee; *4*, through bones of leg; *5*, through the ankle; *6*, through bones of the foot; *7*, through bones of toes.

In the case of the fore limbs (Fig. 31) seeing is knowing, for no one can doubt that they are all made on the same plan. Their differences are chiefly differences of arrangement, and, though in some cases bones have disappeared, in no instance do any *additional* bones appear.

As in the fore limbs, the similarity in the arrangement of the hind limbs (Fig. 32) is most striking. The dotted line *5* should be carefully noted; it passes through the ankle-joint in each case—*i.e.*, it passes just above the foot. The foot of man and ape is plantigrade—*i.e.*, the whole foot is placed on the ground—but the rest walk on their toes. This is a point of great importance, for without this there could have been no erect position in walking, and so there could have been no man.

In the case of man the leg stands almost perpendicularly over the foot. This is the upright position which thousands of years' practice has given him.

The hind limbs should be carefully compared with the fore limbs, and this would show that both hind and fore limbs have a similarity of plan. "The thigh-bone, or femur, corresponds to the shoulder-bone, or humerus; the two shank-bones (tibia and fibula) correspond to the two arm-bones (radius and ulna); the many little ankle-bones (tarsals) correspond to the many little wrist-bones (carpals); the foot-bones (metatarsals) correspond to the hand-bones (metacarpals); and, lastly, the bones of each of the toes correspond to those of each of the fingers."

So striking are the adaptations of the fore limb in Fig. 33 that this plate is repeated from Part I. Greater modifications of the fore leg can scarcely be imagined, yet the general plan is easily seen to be the same in the three widely different species of animals. These arms or fore limbs point emphatically to a common ancestral group as the one source of their origin. That source, as we know by other proofs, was the five-toed, roof-headed amphibians (stegocephala).

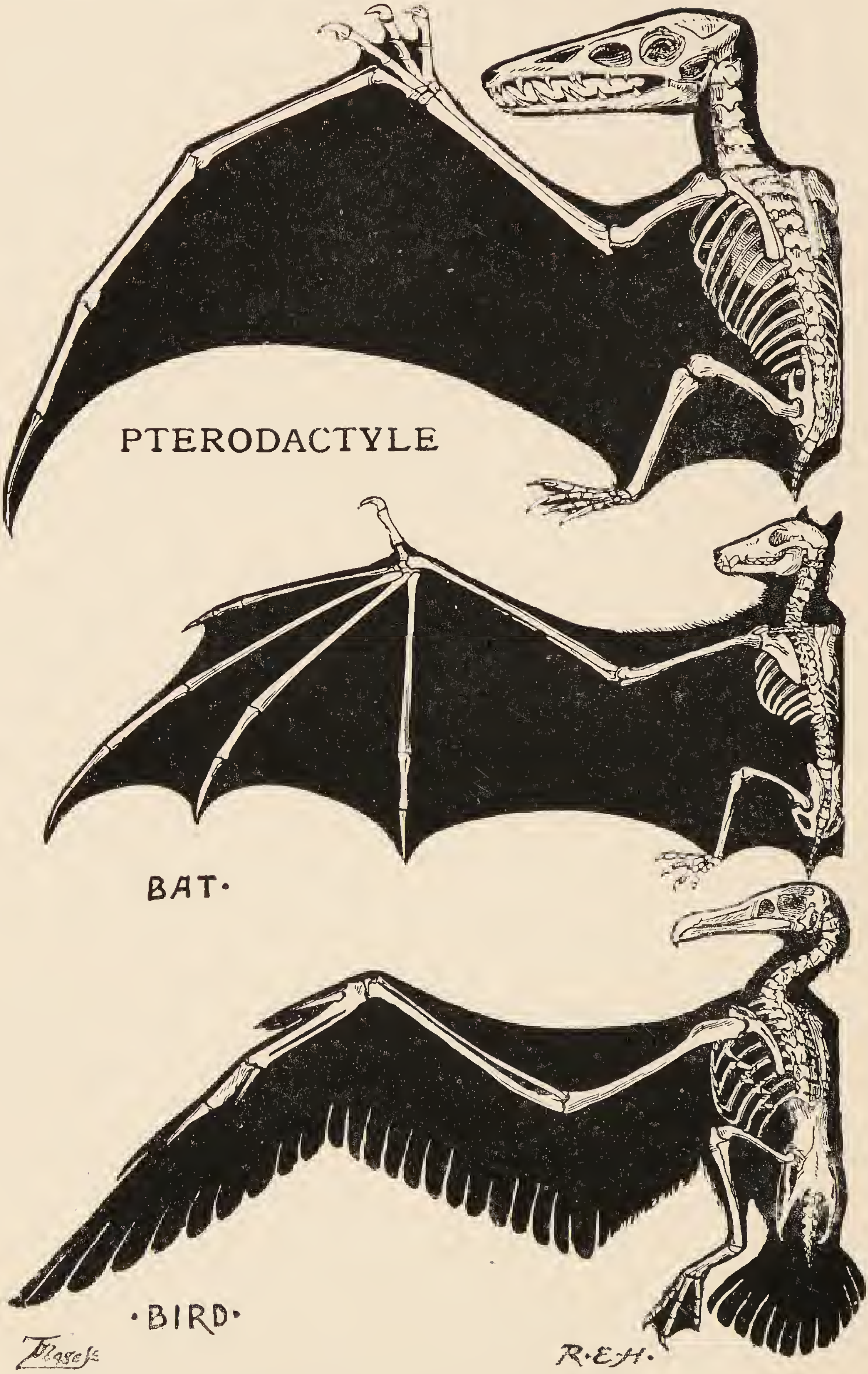
PTERODACTYLE
BAT·
·BIRD·
Blase sc
R·E·H·

FIG. 33.—Wing of Reptile, Mammal, Bird. The top figure is a flying reptile; the bat is a mammal.

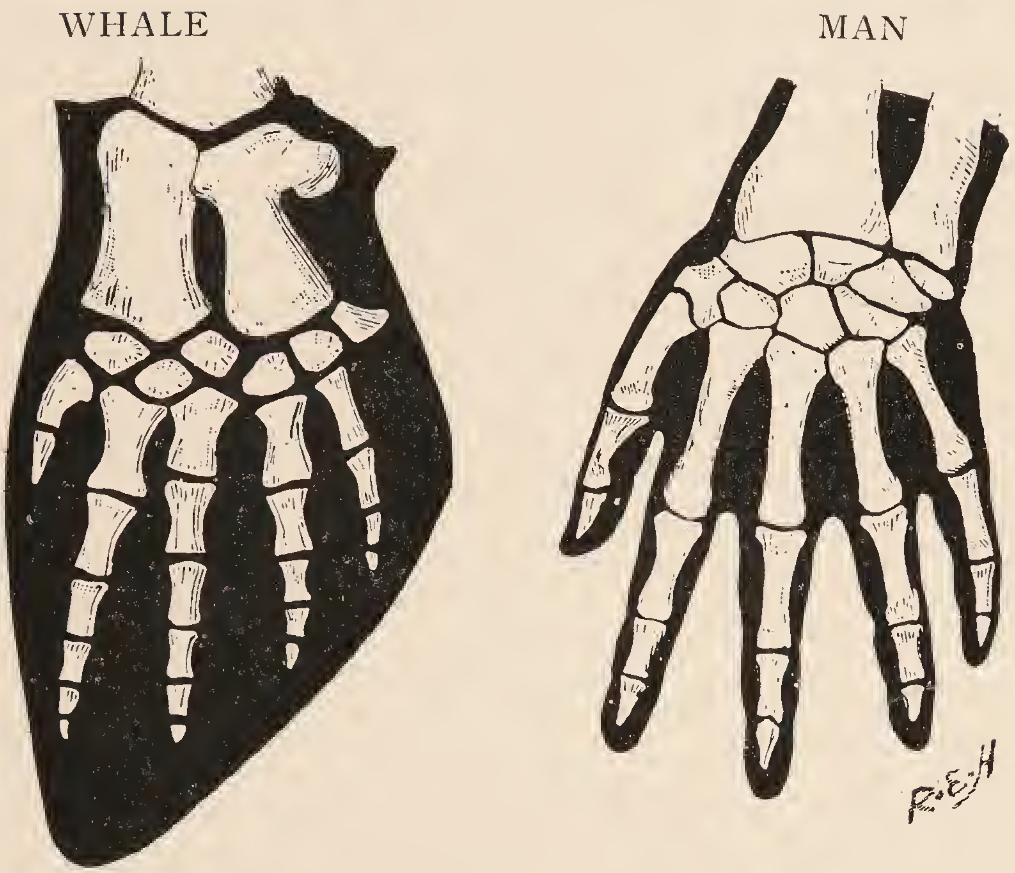

FIG. 34.—The Paddle of a Whale and the Hand of Man.

Fig. 34 shows the hand of the whale and the hand of man; but if we spoke of the *hand* of the whale, we should be sure to be called to order by somebody who had forgotten that the whale is a mammal, and who thought that its arm and hand are simply fins. The arm of the whale is used as a fin, looks like a fin, but when opened there appears a hand with a striking resemblance to the hand of man, though it has degenerated somewhat.

There are few better ways of learning evolution than that of examining some one organ through its various modifications and adaptations.

As we have devoted some time to limbs, we might just glance at their origin.

The limbs were "first evolved in the earliest fishes—the selachii (sharks). From these they have been inherited by all the higher vertebrates—first as polydactyle *fins,* afterwards as pentadactyle *feet.*" The breast-fin or fore limb was originally just the same in structure as the belly-fin or hind limb.

The primitive form of the pairs of limbs (fins), as found in the primitive fishes of the Silurian period,

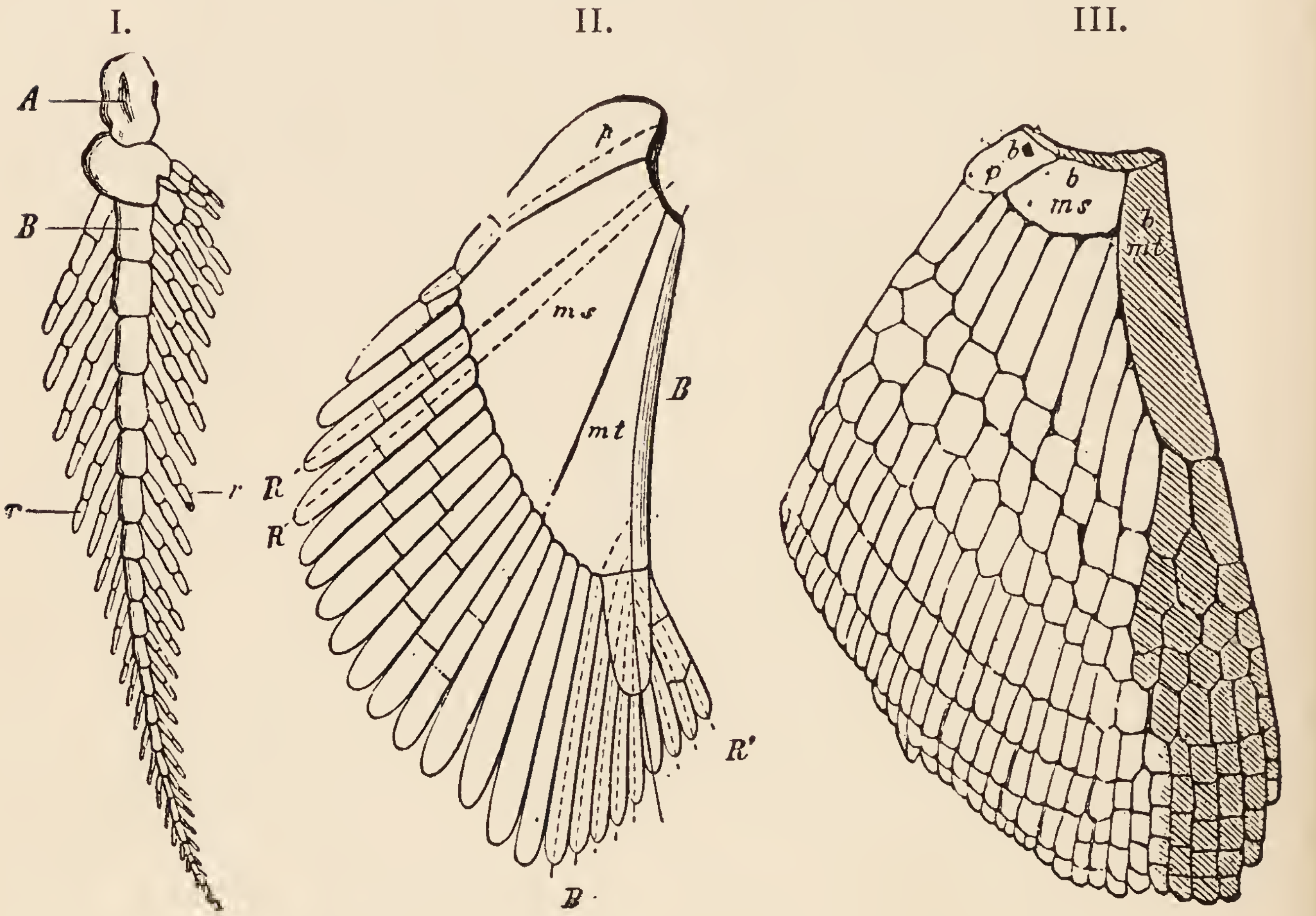

FIG. 35.—Three Breast-fins. I. : Skeleton of the breast-fin of the dipneust, ceratodus ; A, B, cartilaginous series of the fin-stem ; *r, r,* cartilaginous fin-radii. II. : Breast-fin of early shark. The radii of the median fin-border (B) have nearly all disappeared ; a few only (R′) are left ; R, R, radii of the lateral fin-border ; *mt,* metapterygium ; *ms,* mesopterygium ; *p,* propterygium. (*Gegenbaur.*) III. : Breast-fin of a young shark. The radii of the median fin-border have wholly disappeared. The shaded part on the right is the section that persists in the five-fingered hand of the higher vertebrates ; *b,* the three basal pieces of the fin ; *mt, ms, p,* same as in II. ; *mt* is the rudiment of the humerus. (*Gegenbaur.*)

is preserved in the Australian dipneust—the ceratodus, or Burnett salmon (Fig. 113, Part I.). These fins are flat, oval paddles, with a biserial cartilaginous skeleton (Fig. 35, I.).

This fin began to change till it lost the radii on one side (Fig. 35, I. and II.). Most of the radii on the other side also disappeared, till only the shaded part of Fig. 35, III., remained.

If you carefully compare the breast-fin of the shark (Fig. 35, III.) with the foreleg of the amphibian (Fig. 36, I.), you will see how the limbs of animals arose from the fins of fish.

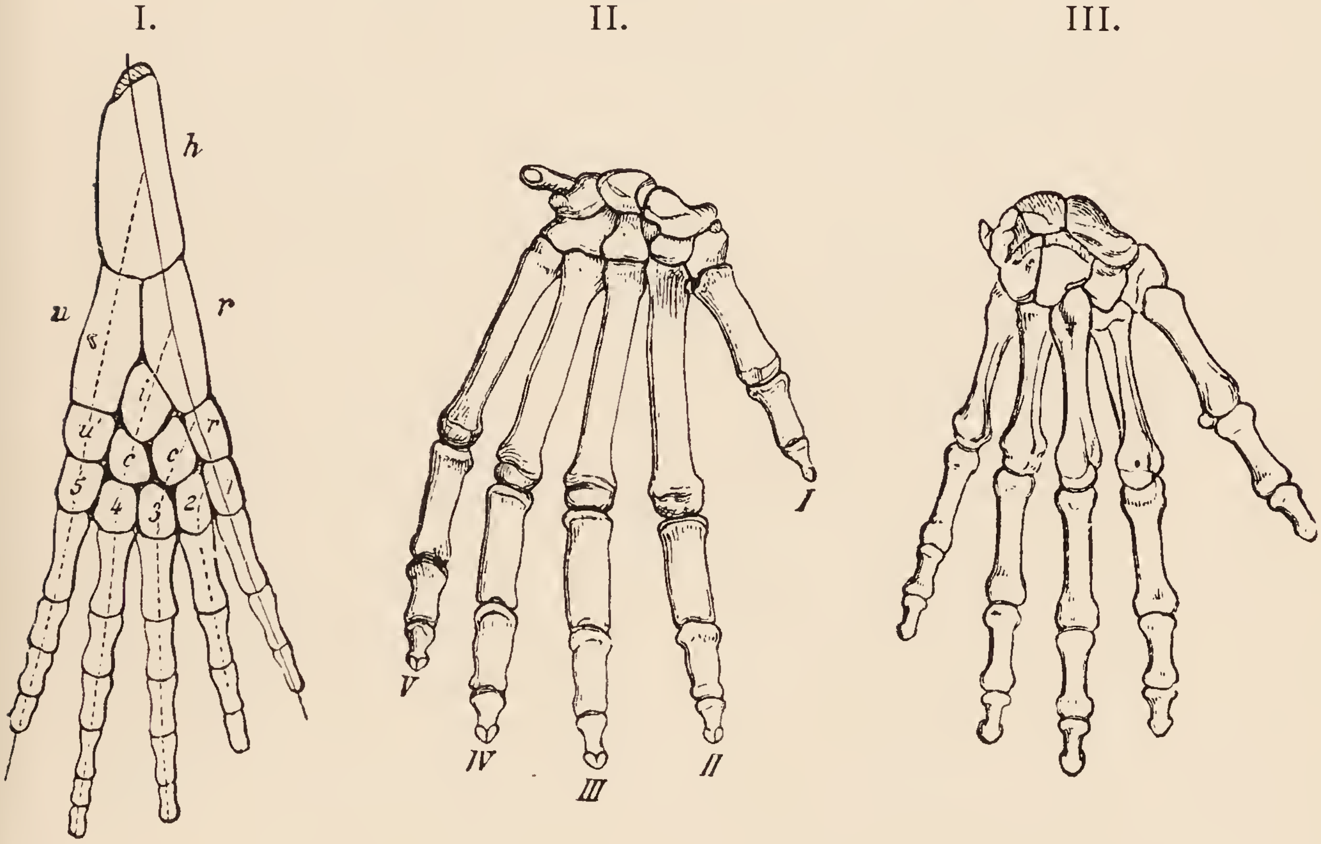

FIG. 36.—Three Skeletons of Right Hands, seen from the back. I.: Fore leg of amphibian. *h,* upper arm (humerus); *r, u,* lower arm (*r,* radius; *u,* ulna); *r, c, i, c, u,* wrist-bones of first series (*r,* radiale; *i,* intermedium; *c,* centrale; *u,* ulnare); *1, 2, 3, 4, 5,* wrist bones of the second series (*Gegenbaur*). II.: Gorilla's hand. III.: Human hand.

It should be noted that the long black line, in the amphibian leg, which passes through *h, r, 1,* should pass through *h, u, 5,* for the fin-rod has been found to pass through the outer side.

It is not yet quite clear how the fins themselves originated. Gegenbaur thinks from two pairs of

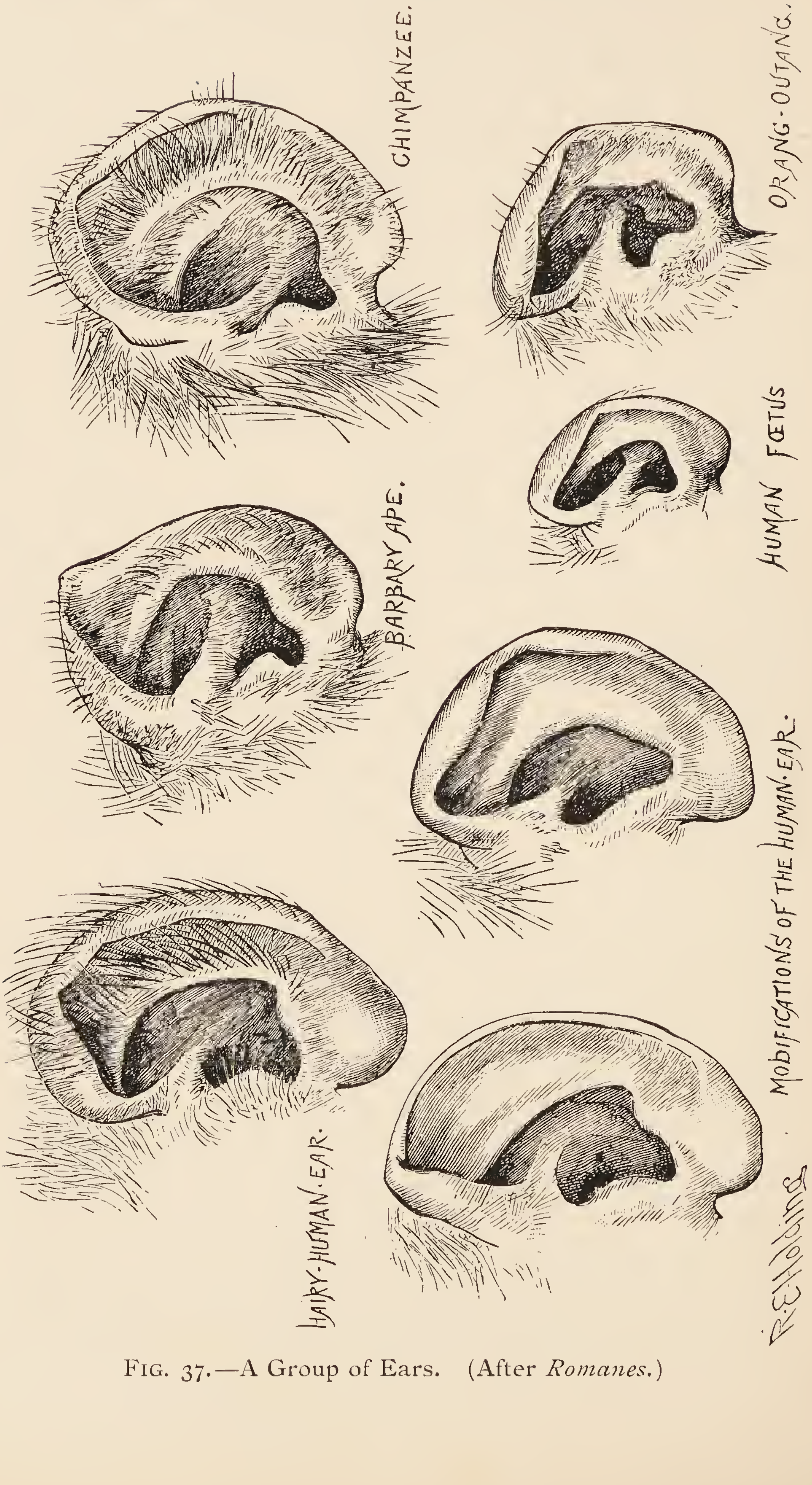
CHIMPANZEE.
ORANG-OUTANG.
HUMAN FŒTUS
BARBARY APE.
MODIFICATIONS OF THE HUMAN·EAR.
HAIRY·HUMAN·EAR.
R.E.Holding

FIG. 37.—A Group of Ears. (After *Romanes.*)

posterior separated branchial arches. Balfour holds they are derived from a pair of lateral folds of the skin.

We shall not be able to devote so much time to each organ or set of organs as we have to the limbs, but we may look at a few specimens of others, which may afterwards be studied more fully in Haeckel's *Evolution of Man*.

Man has many organs, or modifications of organs, which are no longer of any use to him. Such organs are called rudiments or vestiges. The ears in Fig. 37 are given to show remarkable points of similarity; for instance, that of the human fœtus closely resembles that of the orang, while the two larger in the lower line show ape-like points, as their small lobes, and the outer margin of one is not unlike that of the Barbary ape, and the other follows the chimpanzee and orang. When we remember that the whole of the outer ear in man is a vestige of movable ears, these points of likeness are still more wonderful.

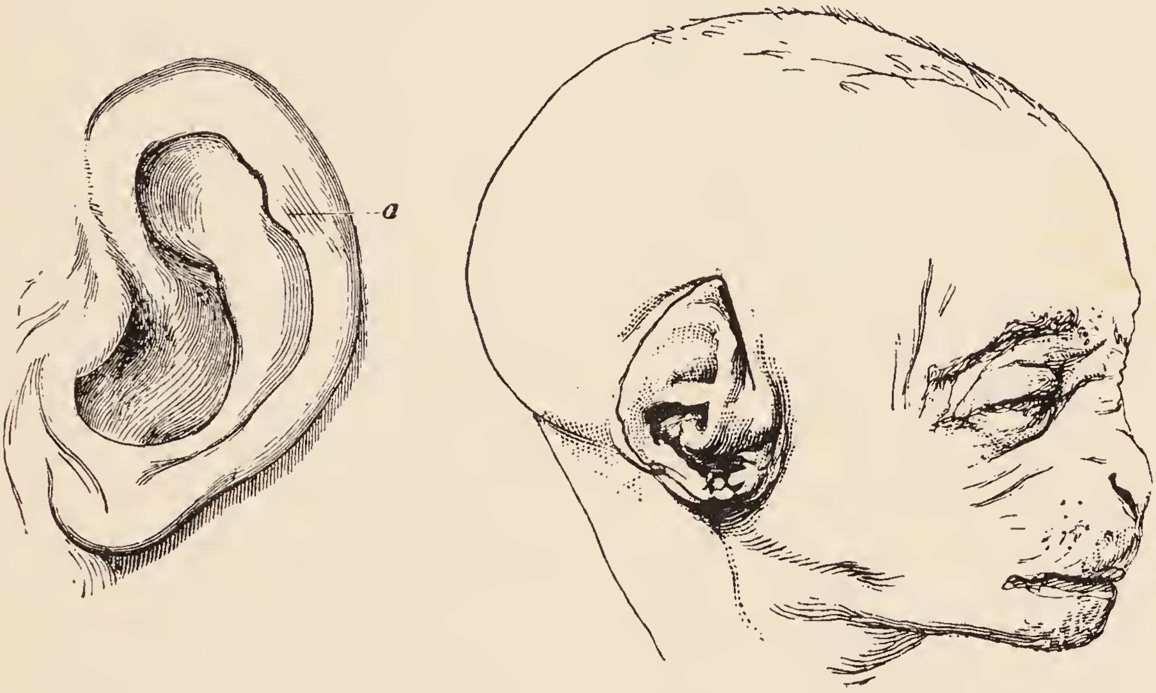

FIG. 38.—A Human Ear and Fœtus of Orang. (After *Romanes.*)

The photograph of a young orang (before birth) shows a much earlier stage of the ear in its pointed form (Fig. 38). It is given here side by side with a human ear to show the very interesting point marked *a* in the human ear. This point *a* is named the Darwinian lobe. It is the pointed tip of the ear (as seen in the young orang) folded over. It is often found in both men and women; it is developed at birth; and it is more frequent in men than women.

Grown-up man presents rudimentary hair over most parts of the body. In the case of the arms it is peculiar, for the hair on the upper arm is directed to the elbow, and the hair on the lower arm is directed to the elbow. This peculiarity occurs nowhere else in the animal kingdom except in the anthropoid apes and a few American monkeys (Fig. 39). It is supposed to be due to living in trees. For, when sitting in trees, the orang, as observed by Mr. Wallace, places its hands above its head, with its elbows pointing downwards; the disposition of hair on the arms and fore-arms then has the effect of thatch in turning the rain.

There seems to be no other explanation of this peculiarity, and these hair-tracts, therefore, are a remarkable record of family history, for they point back to a habit which man's ancestors must have practised for tens of thousands of years. Very interesting are these wonderful records, for, as I look at them, I see not only a remarkable relic of our hairy ancestors, but also a time-clock which tells of a habit formed in the solitude of the forest and in the solitude of measureless past ages. Before man was these hair-tracts were established; they are one of those remarkable forms of inheritance which man brought with him when he left his prehuman ancestors.

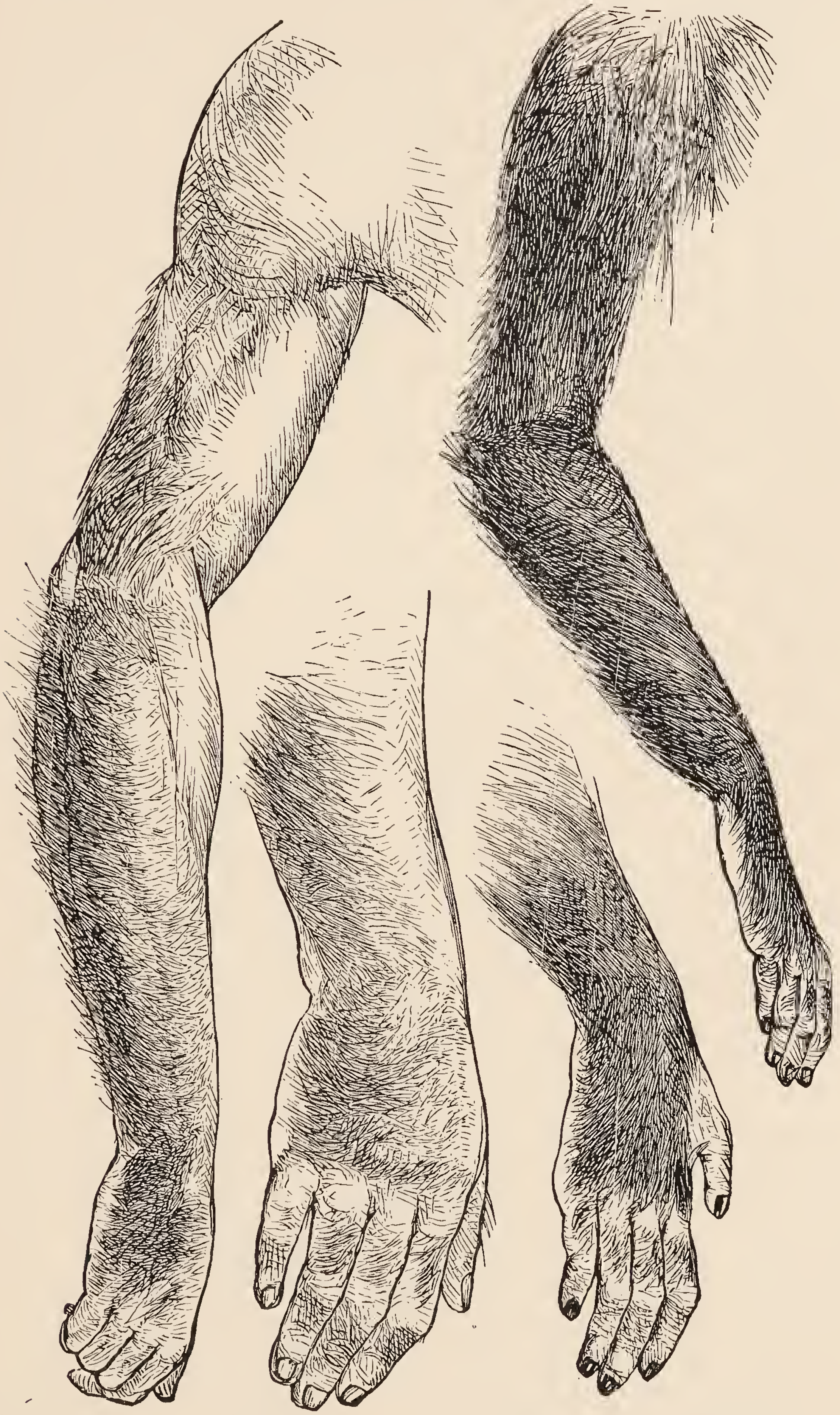
R E Holding
MAN.
MALE CHIMPANZEE.

FIG. 39.—Hair Tracts on Arms. (After *Romanes*.)

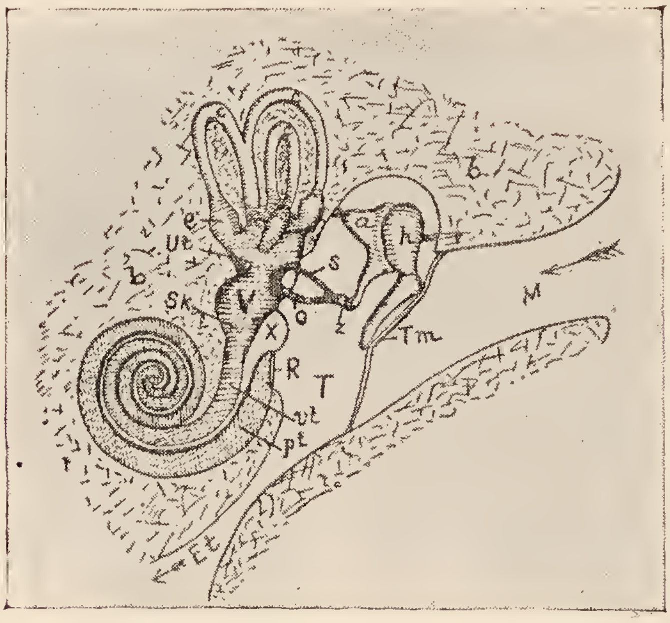

FIG. 40.—Partly diagrammatic scheme of the Ear. *M*, meatus or external opening, arrow pointing in ; *Tm*, drum-head or tympanic membrane ; *T*, drum or tympanic cavity, or middle ear ; *Et*, eustachian tube, arrow pointing to the pharynx ; *h*, hammer, *a*, anvil ; *z*, orbicular bone ; *s*, stirrup resting upon *o* ; *o*, oval window, or fenestra ovalis ; *R*, round window (in profile) or fenestra rotunda ; *c*, three semi-circular canals ; *e*, ampullæ ; *Ut*, utricle ; *Sk*, sacculus ; *V*, vestibule ; Cochlea (*vt*, scala vestibuli ; *pt*, scala tympani ; *x*, scala media) ; *b*, bone.

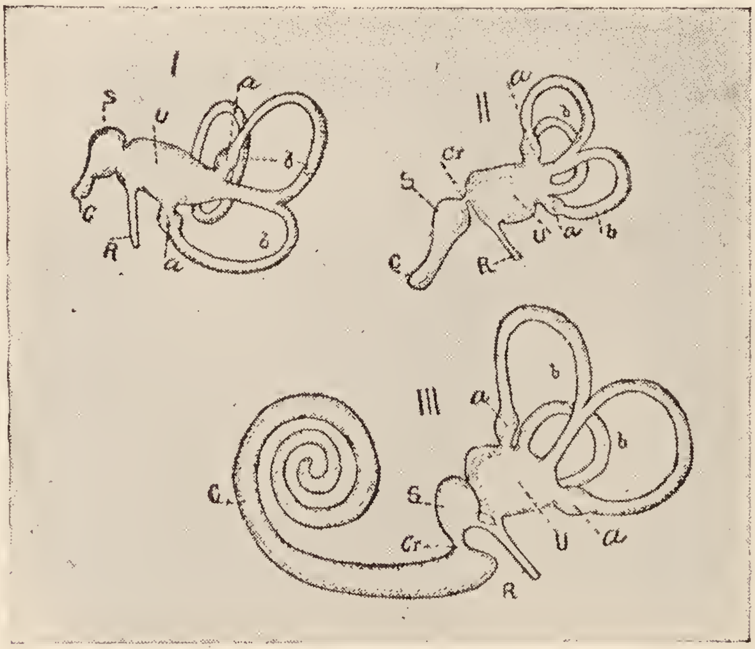

FIG. 41.—Diagrams of Auditory Labyrinth. I.: A fish. II.: A bird. III.: Mammal and man. *S*, sacculus ; *u*, utriculus ; *c*, cochlea ; *Cr*, canalis reuniens ; *a*, ampullæ ; *b*, semi-circular canals ; *R*, aqueduct of the vestibule.

We will next look at the comparative anatomy of a single bone of the ear, called the stirrup-bone.

The general arrangement of that marvel, the organ of sound, is shown (Fig. 40) for reference. The origin of these bones is known, and the wonder of their uses is thereby greatly increased.

These ring-bones (Fig. 41), which form the auditory labyrinth, do not occur in the lower vertebrates. The lowest fishes have only two of these rings instead of three; but, when three were once established, they are found in all the higher vertebrates, as nearly alike as they are seen in this figure.

But still more striking is the stirrup-bone (Figs. 42, 43, 44). Its relationship to the other bones is shown in Fig. 40. It should be borne in mind that the hammer and anvil bones are developed from the *first* gill-arch, the stapes (stirrup-bone) from the second.

In most of these the bone is almost identical. Now it would, indeed, be a miracle if one solitary bone of all these and many more animals, differing so widely in scores of other points, should have been *created* in the same form. If we reflect, we can see that the form of this bone, once acquired, is so sheltered by its position from a change of environment that alteration would be very unlikely to occur.

These stirrup-bones raise a difficulty of which apparently there can be no explanation offered except that given by evolution.

They are undoubtedly derived from the gills by which man's fish-ancestors used to breathe the oxygen in the water at a time when there were no land animals. They form, therefore, one of the marvels of adaptation to which Darwin called special attention.

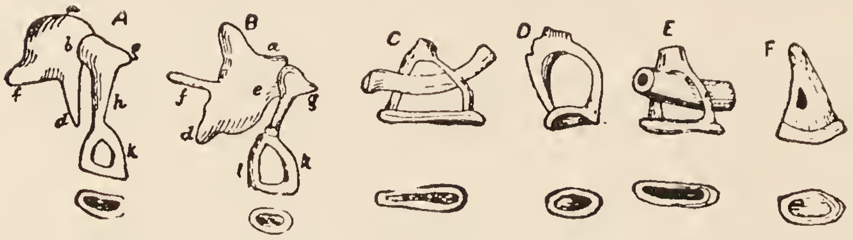
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FIG. 42.—Ear-bones of: A, bat; B, shrew. Stirrup-bones of C, mole; D, hedgehog; E, marmot; F, sloth. Blood vessels are shown running through C and E. The discs at the bottom indicate the shape of the foot of the stirrup. (After *Owen.*)

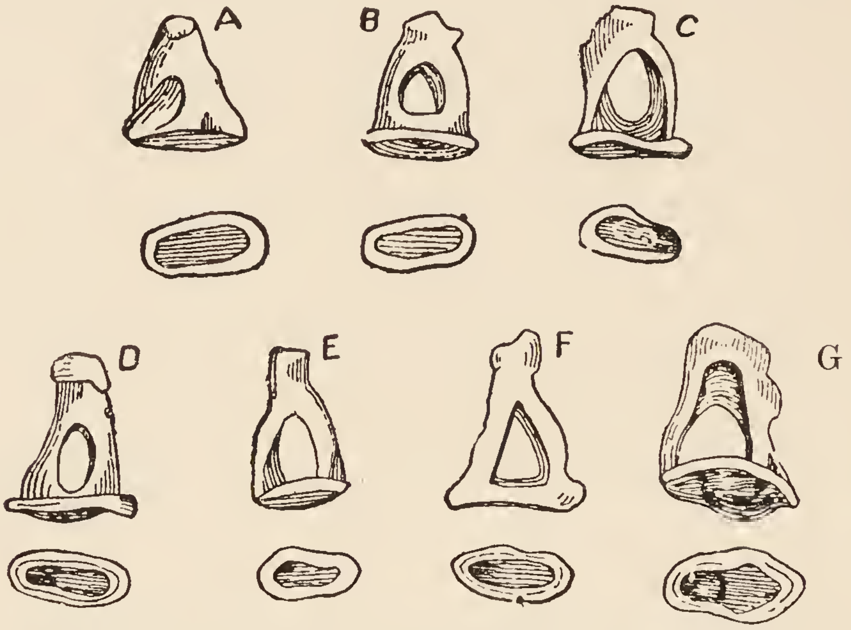

FIG. 43.—Stirrup bone of Ungulate Mammals. A, hippopotamus; B, hog; C, musk-ox; D, horse; E, tapir; F, rhinoceros; G, elephant.

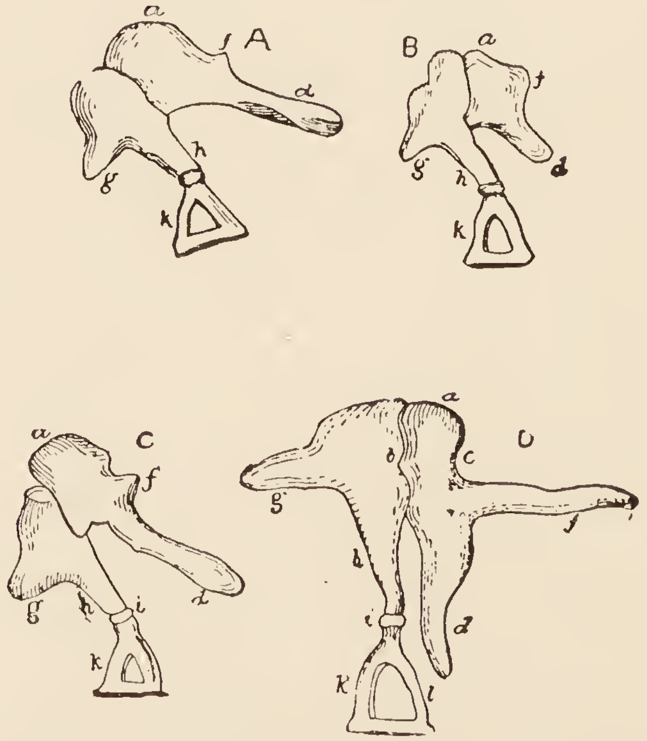
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FIG. 44.—Ear-bones of Monkeys compared with those of Man. A, lemur; B, cebus (a platyrrhine monkey); C, cercopithecus (a catarrhine monkey); D, man.

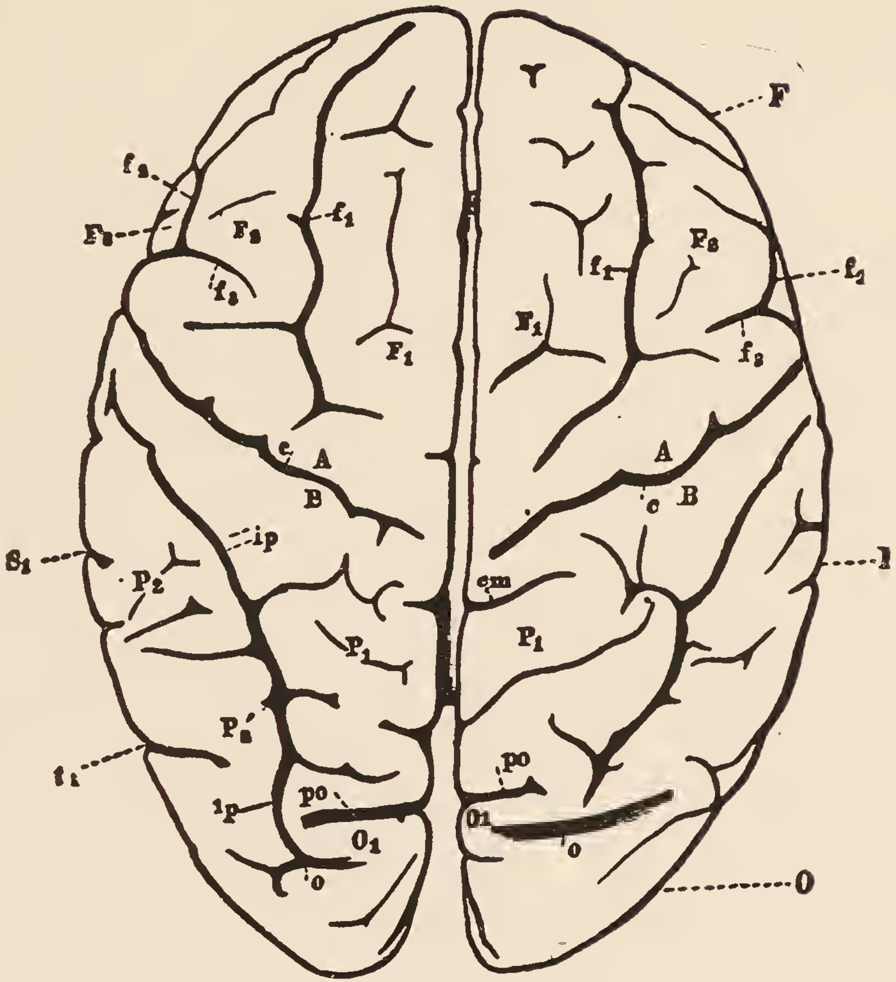
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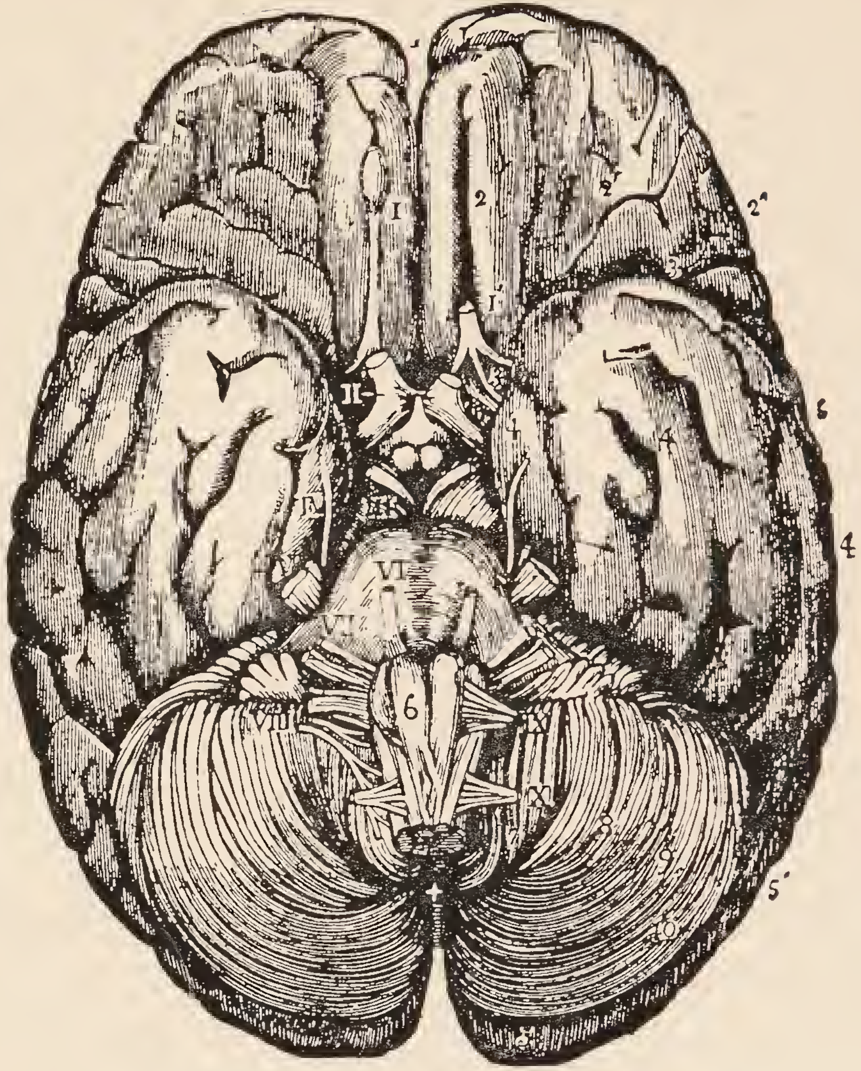
FIG. 45.—Human Brain from above.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2'
2"
1'
II
3
4
4
VI
VII
6
VIII
IX
X
8
9
10
5'

FIG. 46.—Human Brain from beneath.

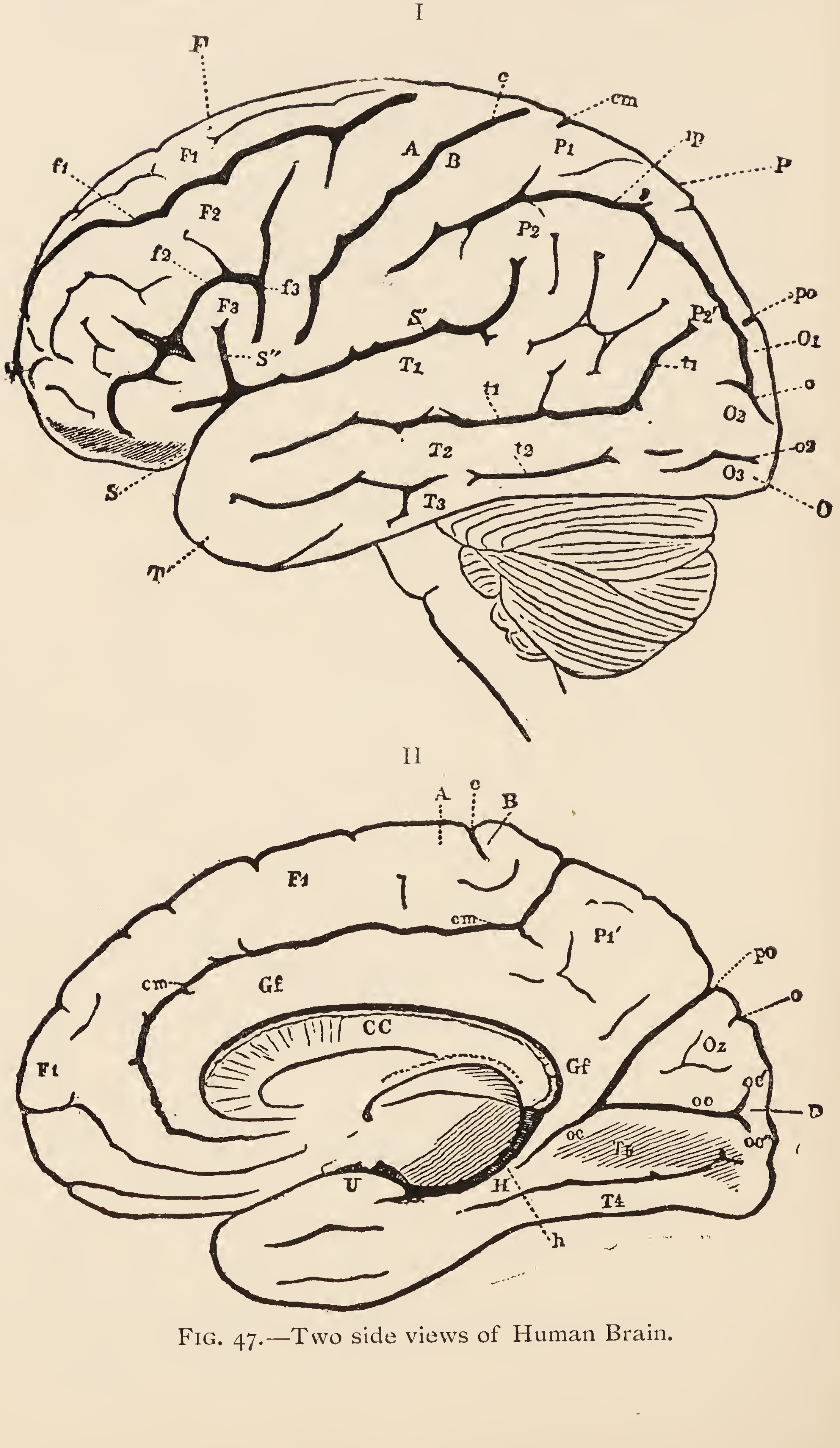
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FIG. 47.—Two side views of Human Brain.

Fig. 45 shows the brain, as seen in its place if we look down on its top surface. The whole of this is called the cerebrum, or the two cerebral hemispheres. You see a broad line dividing it in the middle ; this is the dividing line between the two hemispheres. The numerous black lines show where the brain is divided into folds or convolutions. They are of the utmost importance, for by being folded upon itself in this way there is a much larger area of brain than would be otherwise possible in the same space.

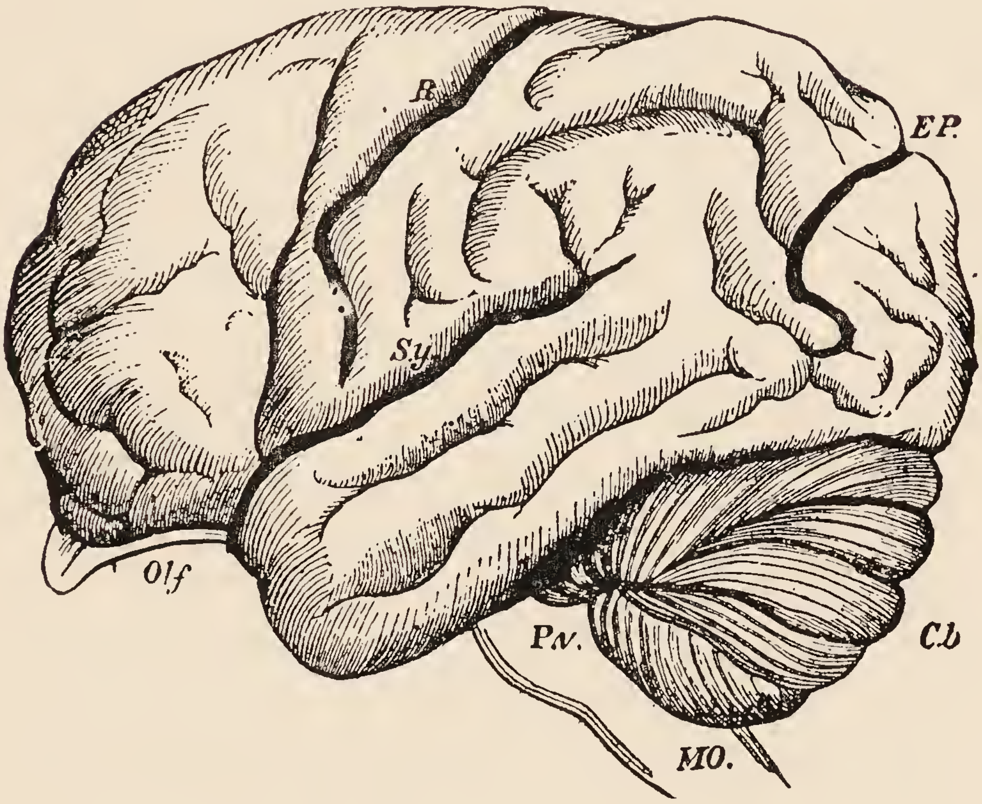


Fig. 48.—Side view of the Brain of Orang.

Fig. 46 is the view we should have if we took a brain out of the skull and turned it over. In the central part you can see the ends of many nerves which have been cut off.

In Fig. 47 the one above (I) is the view of the outer brain as it would appear if the side of the skull were removed. It seems to rise from a stalk; that narrow portion is where the spinal cord joins the brain. A small mass, below the hemisphere,

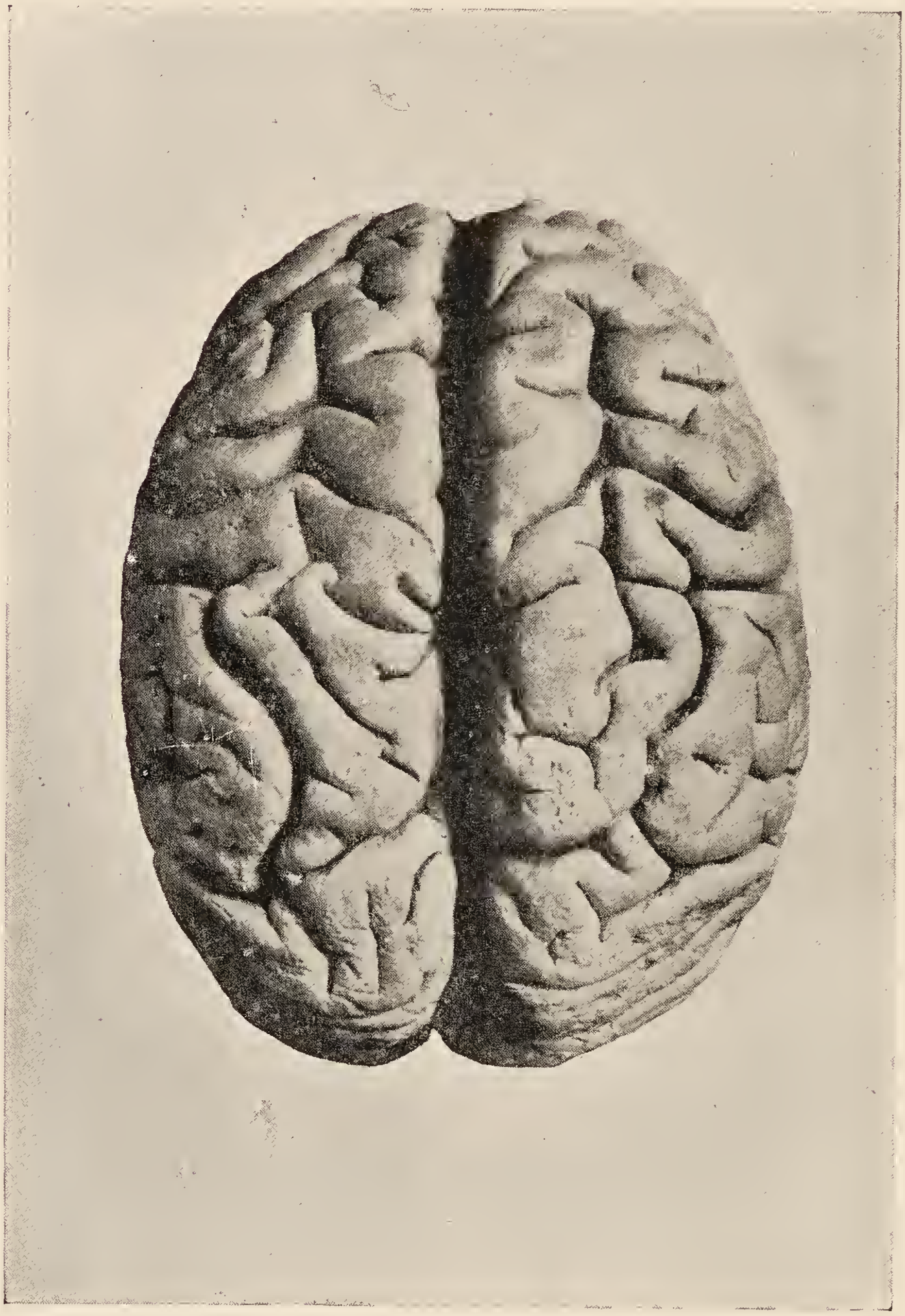


FIG. 49.—Brain of the Chimpanzee, Sally.

all covered with lines, is that portion of the hind brain called the cerebellum. Note that it is completely covered above by the large hemispheres of the cerebrum.

The picture below (II) is a view of the right hemisphere of the brain, such as one would get if a sharp instrument were passed down through the brain between the two hemispheres. The peculiar sort of half circle, marked CC, is the celebrated corpus callosum, or great commissure; this part joins the two hemispheres together.

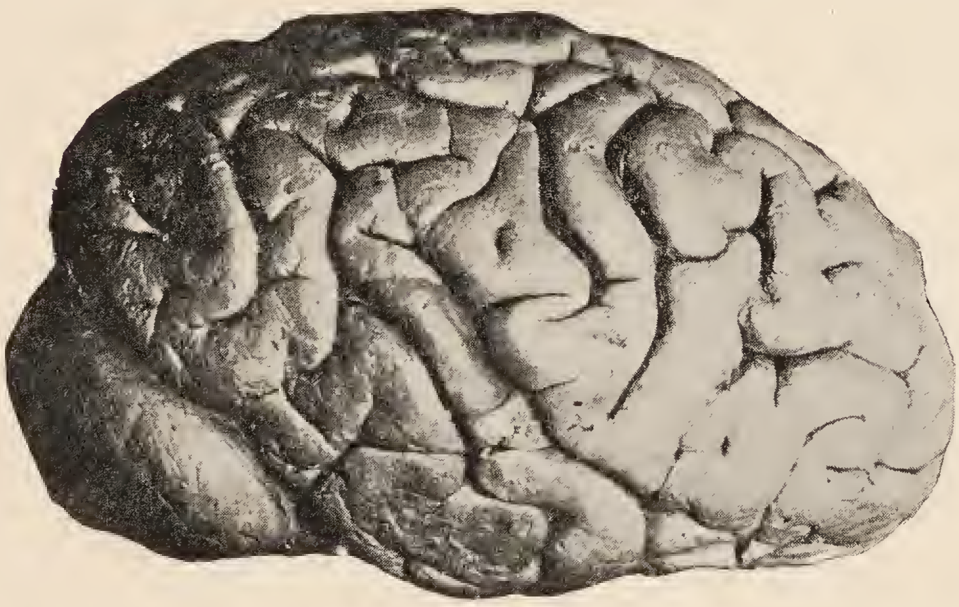


FIG. 50.—Side view of the Brain of Sally.

The side view of the brain of the Orang (Fig. 48) should be carefully compared with the same view of the human brain (Fig. 47, top picture), when it will be seen that the two agree in their general plan and formation.

Fig. 49 is interesting as the brain of that very

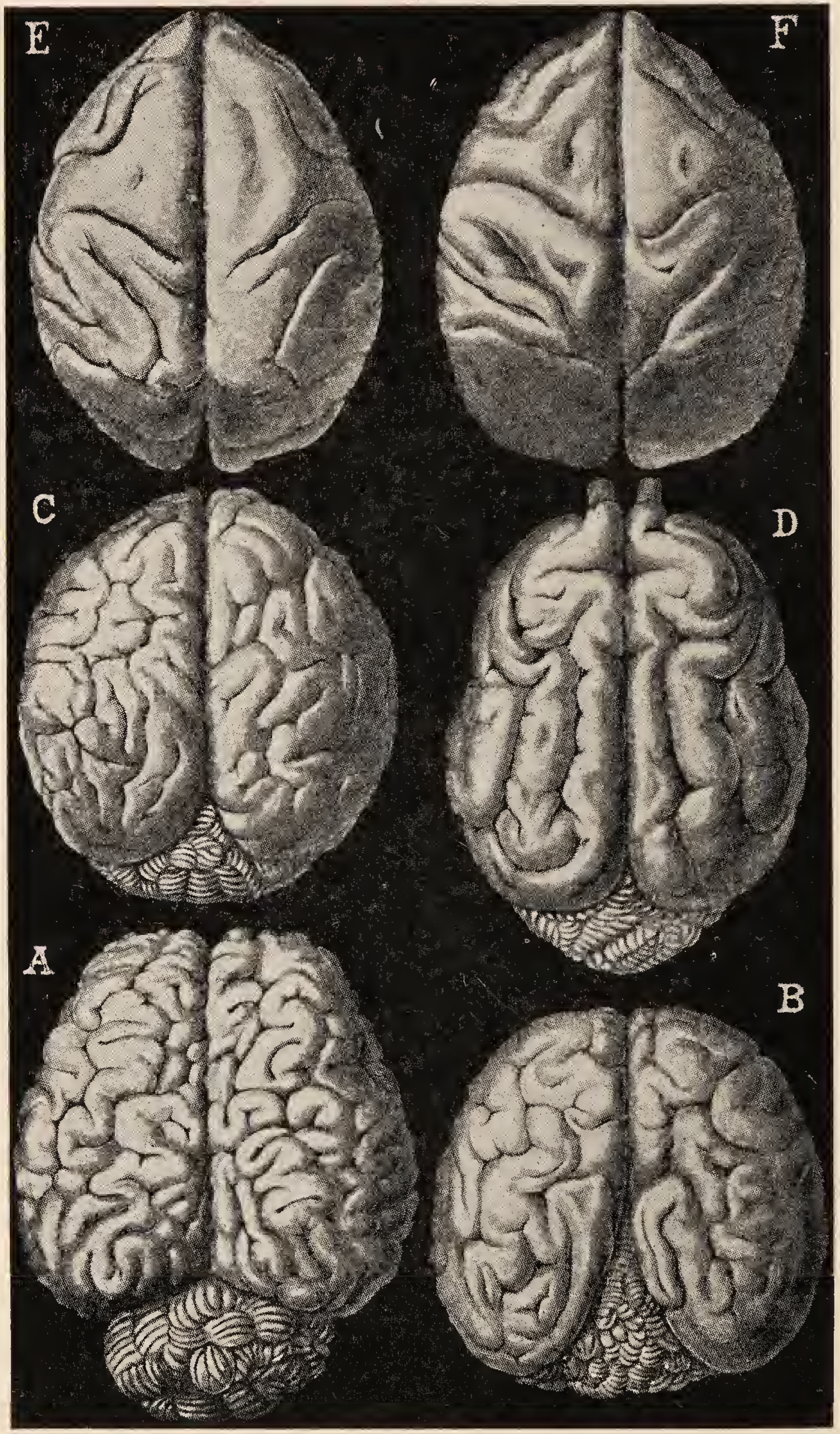


FIG. 51.—Six Mammal Brains. A, giraffe; B, seal; C, dolphin; D, lion; E, semnopithecus (ape); F cercopithecus (monkey).

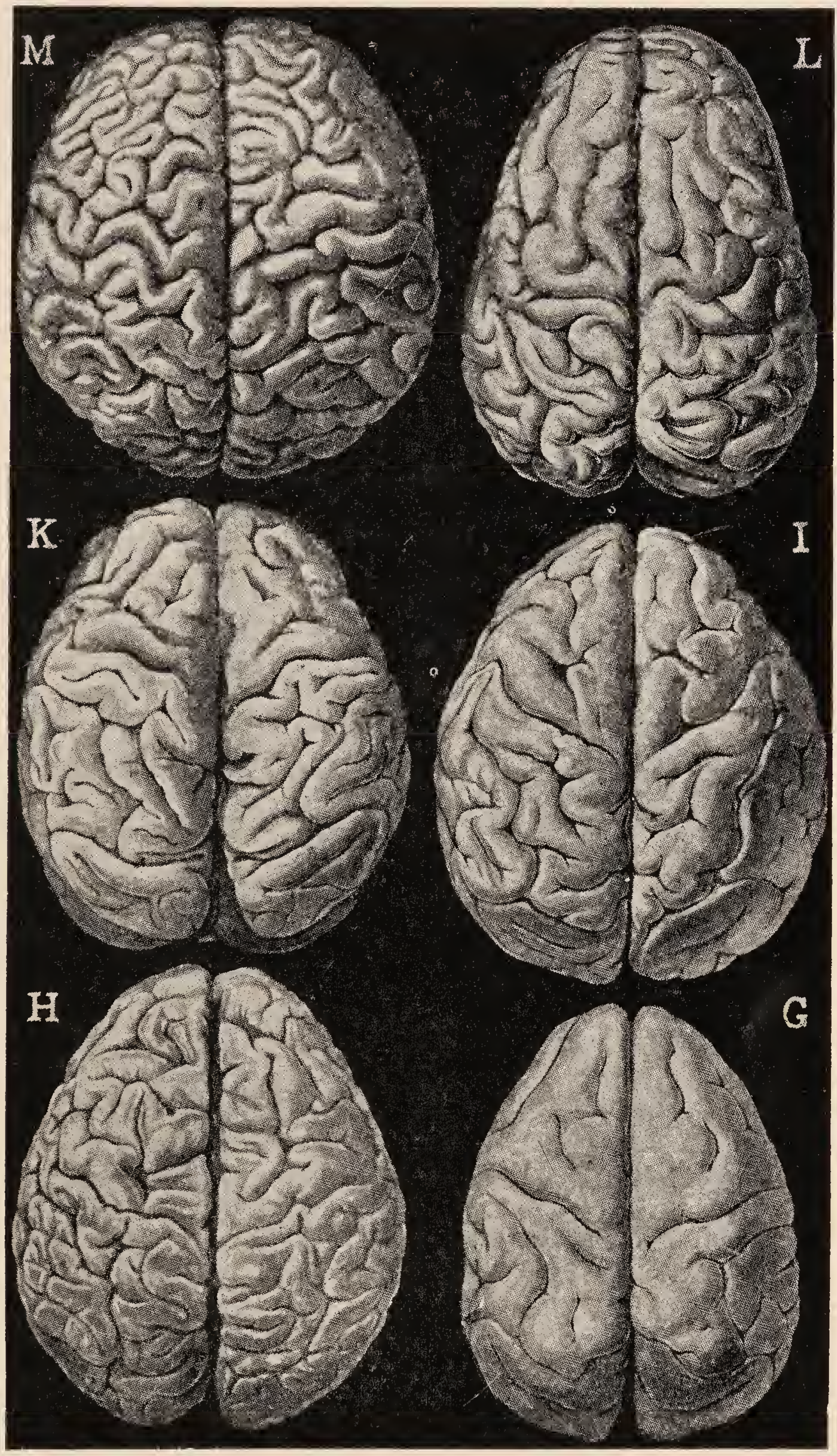


FIG. 52.—Six Brains of Apes and Men. G, gibbon; H, chimpanzee; I, orang; K, gorilla; L, bushman; M, man.

clever ape, Sally, late of the Zoological Gardens, London (shown in Fig. 162, Part I.).

Figs. 51 and 52 tell their own story pretty well. It should be noticed that in the cases of mammals A, B, C, D, the cerebellum is not covered by the cerebral hemispheres.

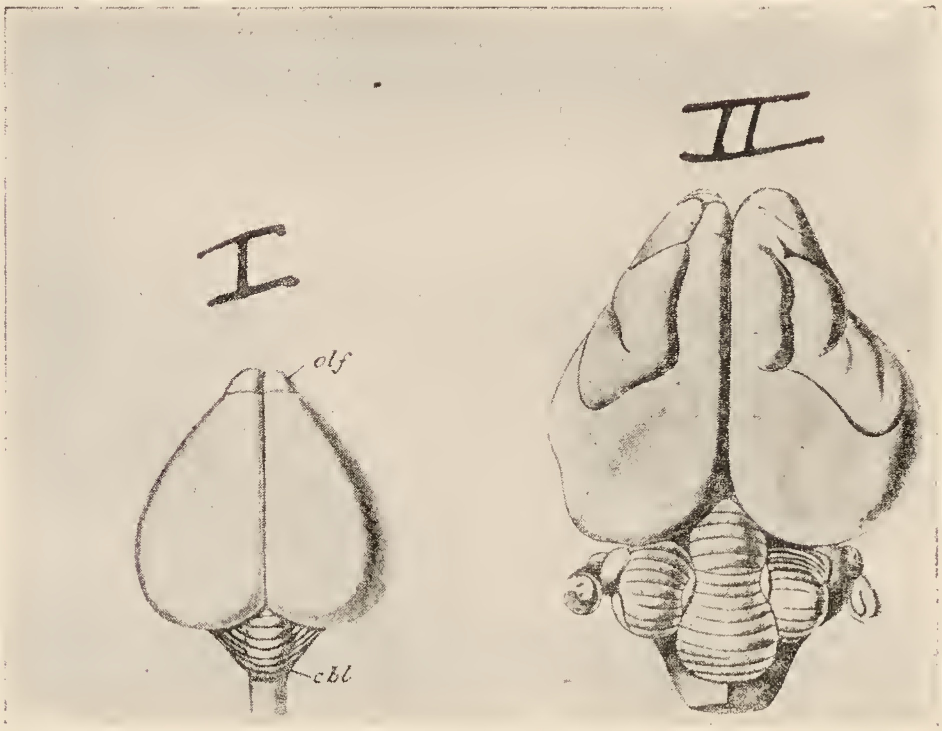


FIG. 53.—Brains of the Duck-mole and Kangaroo. I., brain of the duck-mole (ornithorhynchus), dorsal view, natural size; *cbl,* cerebellum; *olf,* olfactory lobes. II., kangaroo (macropus). (After *Owen.*)

In the brain of the duck-mole (Fig. 53 I.) we see that the cerebral hemispheres have become so enlarged as to fill nearly the whole upper space of the skull and partly to cover the cerebellum. Note how extremely smooth these hemispheres are. In the kangaroo (Fig. 53 II.) the brain is not only larger, but it is no longer smooth. Those divisions, or furrows, which become so marvellous in the brain of man are just beginning to make their appearance.

Observe how remarkably smooth the brain of the midas and the human fœtus (Fig. 54) are, and, though there is only one real fissure (the Sylvian fissure), it is *the same* in both!

Brains begin alike wherever they begin.

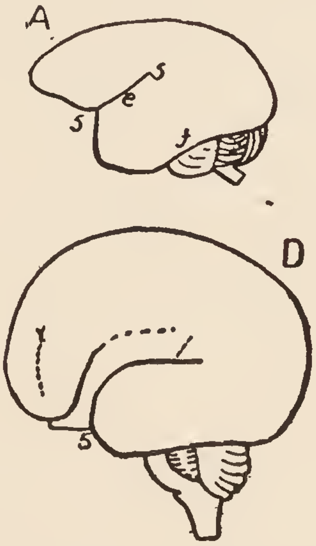


FIG. 54.—External surface of the left hemispheres of: A midas (a marmoset); D, human fœtus (5 months).

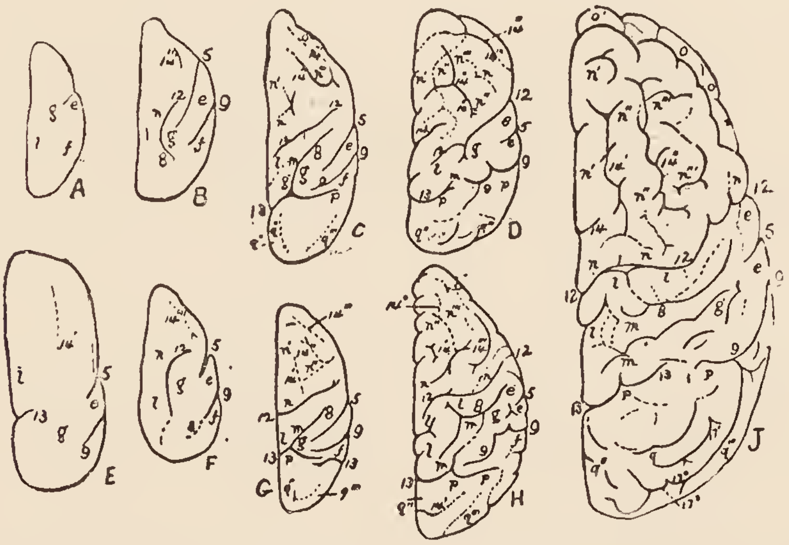
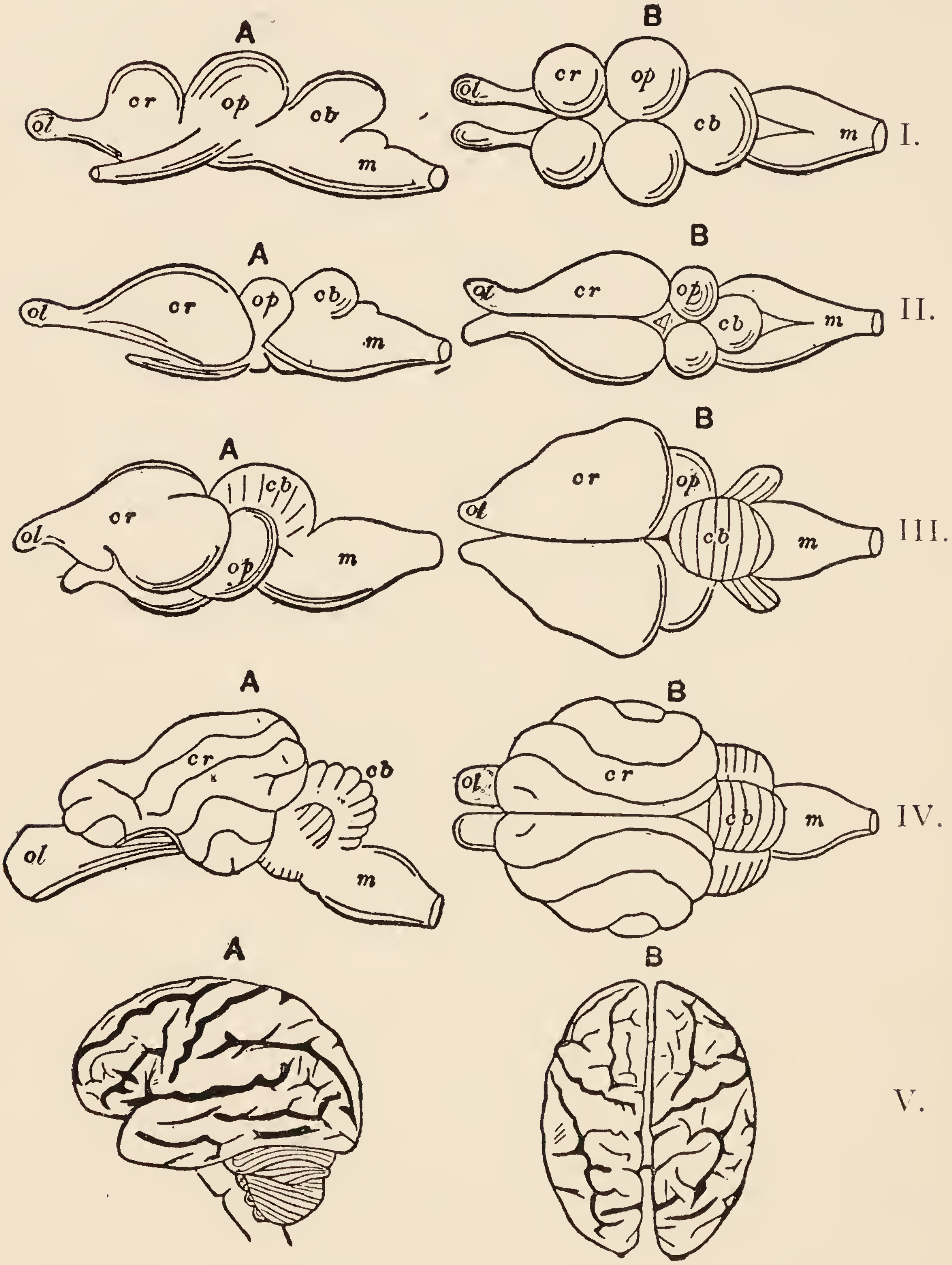


FIG. 55.—Convolutions of Brains of Monkeys, Apes, and Man. A, midas (marmoset); B, callithrix (squirrel-monkey); C, macaque (monkey); D, human fœtus (7 months): E, human fœtus (3 months); F, lemur; G, cebus (monkey); H, chimpanzee; J, adult man.

In Fig. 55 the observant student can pursue the comparison still farther. It is not necessary even to learn the names of the lobes, convolutions, and fissures. The numbers and letters refer to the same parts, and by them parts can be identified. The various steps of development and the growing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op
m
III.
A
B
cr
cb
ol
m
IV.
A
B
V.

FIG. 56.—Comparative series of Brains. The line A gives the side view; the line B gives the view seen from above. I., fish; II., reptile; III., bird; IV., mammal; V., man. The small letters indicate the same part in each case: *m*, medulla; *cb*, cerebellum; *op*, optic lobes; *cr*, cerebrum; *ol*, olfactory lobes. (After *Romanes*.)

likeness to the brain of man are, indeed, striking. Most noteworthy is the fact that the *fœtal* human brain resembles that of the lower monkey family.

This comparative series (Fig. 56) of brains shows a progressive consolidation and enlargement of the brain in general, and of the cerebrum and cerebellum in particular.

Especial attention should be given to No. I., the brain of the fish. There we see five round bodies ; the two on the left are the cerebral hemispheres, with long protruding parts. These parts are the olfactory lobes, the organs of smell.

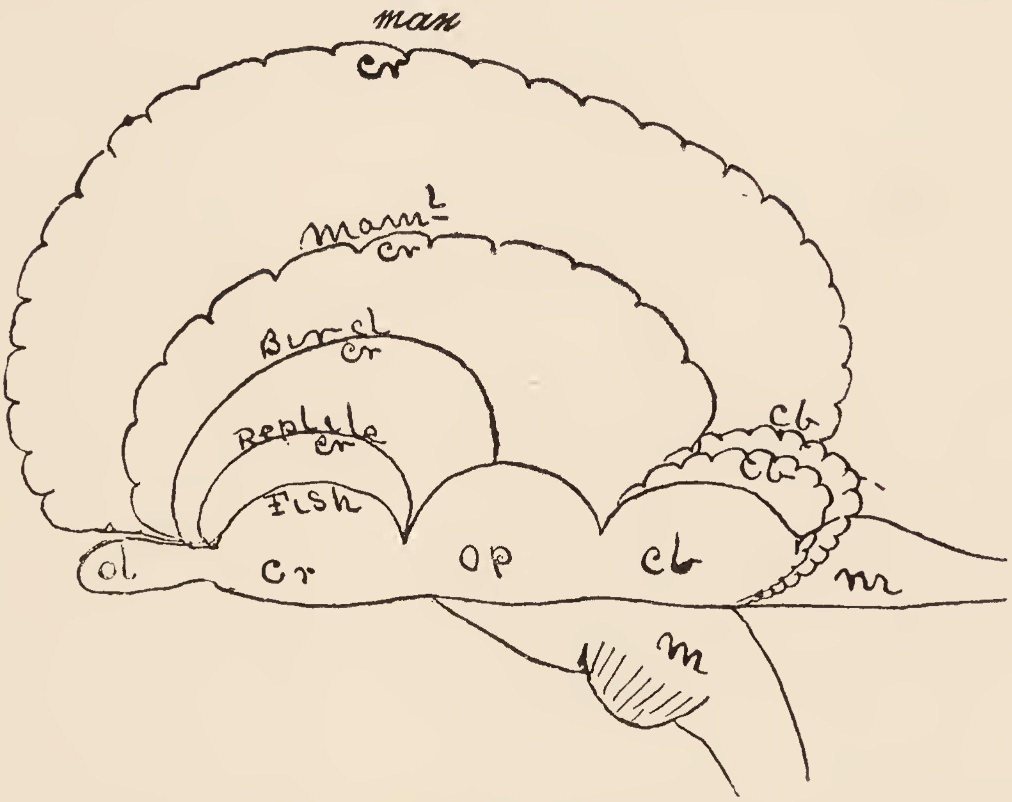


FIG. 57.—Ideal section through the five stages shown in the preceding figure. The small letters indicate the same parts as in the preceding figure.

The two bodies in the centre are the optic lobes, connected with the eyes. Without this connection we should not be able to see.

The one body on the right, *cb,* is the cerebellum or hind brain.

These five bodies, forming the brain of the higher fish, have a wonderful lesson for us, if we study brain development, as we shall see.

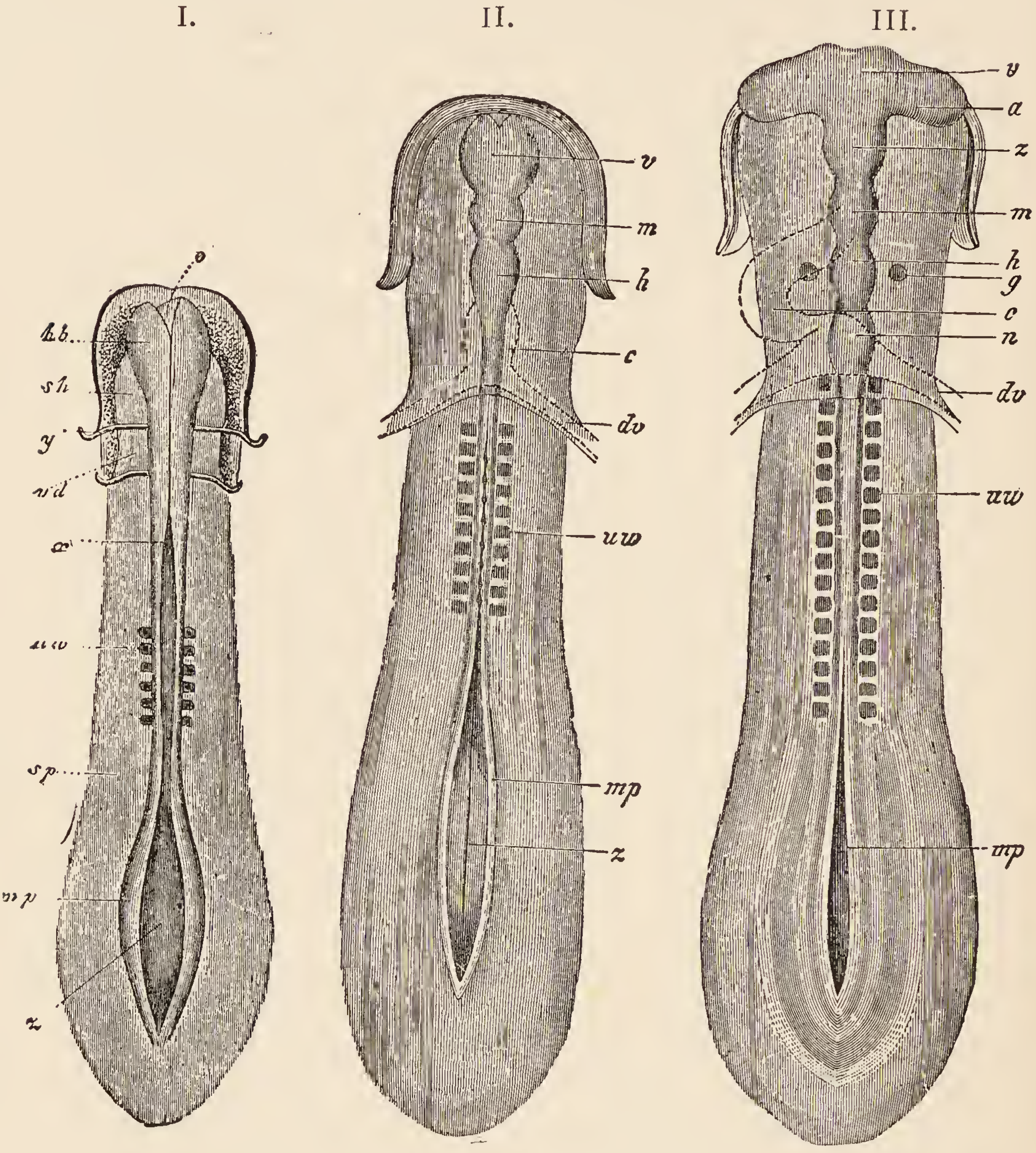


Fig. 58.—Three Embryonic Chickens in three successive stages of development, dorsal view, magnified about twenty times. I., brain a simple vesicle (*hb*). Medullary furrow still wide open from *x*; much enlarged behind at *z*. II., brain divided into three vesicles: *v*, fore brain; *m*, middle brain; *h*, hind brain. III., brain divided into five vesicles: *v*, fore brain; *z*, intermediate; *m*, middle; *h*, hind; *n*, after brain; *o*, optic vesicles.

These series of brains should be carefully studied; and it should be noted that, while some parts greatly enlarge, others diminish, as the lobes for smelling.

Fig. 58, showing these three early stages of chicken brains, is exceedingly helpful in understanding the beginning and growth of the brain. In I. we observe that the spinal cord, which runs nearly the whole length of the body, expands into a bulge at the top, just as it does in the ascidian and amphioxus (see Figs. 104 and 105, Part I.).

In II. it is dividing into three round bodies ; this is the *permanent* stage of some of the lower fish.

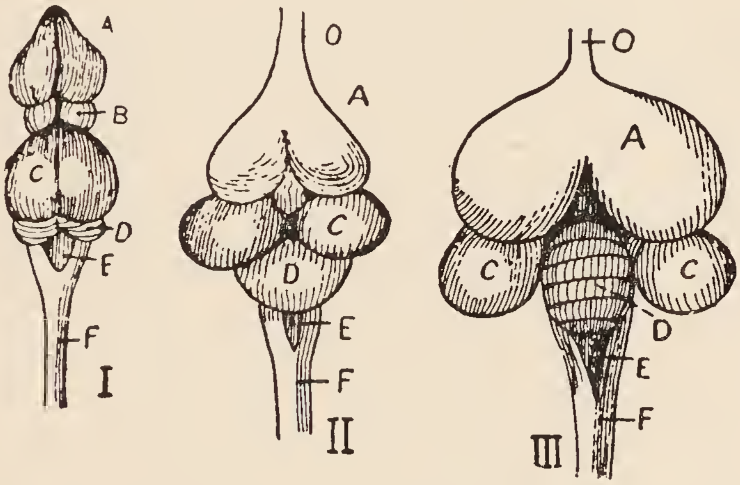


FIG. 59.—Brains of Embryo Chicks. I., 8 days ; II., 16 days ; III., 20 days. Letters same in all—O, olfactory lobes ; A, hemispheres of the brain ; B, optic thalamus ; C, optic lobes (corpora bigemina) ; D, cerebellum ; E, fourth ventricle ; F, spinal cord.

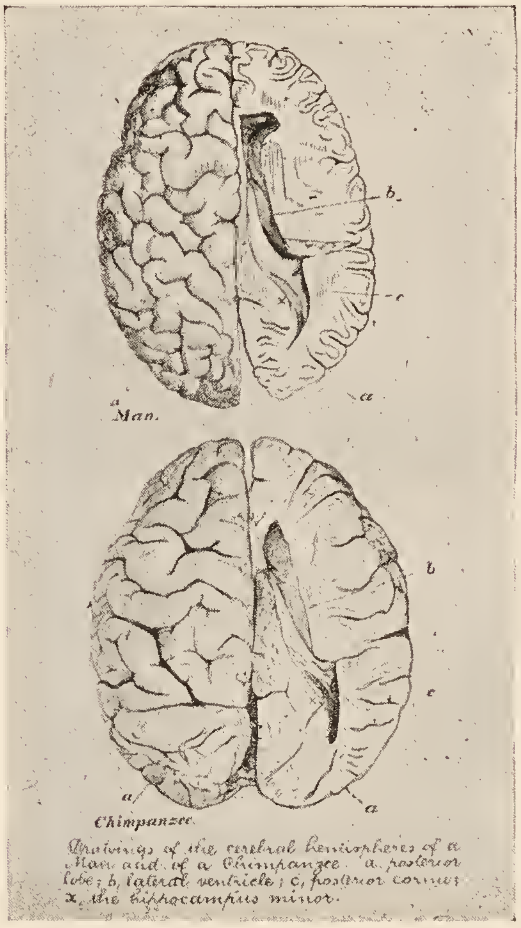
In III. there are five of these small bodies, as we have just seen there are in the higher fish.

It is remarkable that the brain of a chicken should develop by the stages which are followed by the ascidian, the amphioxus, and the lower and higher fish.

Still more remarkable is it that this is the mode of development of the brain from the simplest fishes to man ! Such is the simple beginning of that organ from which is produced the brilliant reason and the dazzling imagination of man.

In Fig. 59 we see the development of the brain of the chicken carried on much farther. It is very instructive to compare these figures with Nos. I. and II. in Fig. 56.

Notwithstanding the clear proofs of the gradual development of the brain, and the overwhelming number of points of agreement between the brain of man and that of the higher apes, many said: "It is only an outside resemblance. Cut into it, and you will find most important points of difference." So Huxley dissected the brains of apes to see. In Fig. 60 we have the result.



Drawings of the cerebral hemispheres of a Man and of a Chimpanzee. a. posterior lobe; b, lateral ventricle; c, posterior cornu; x, the hippocampus minor.

FIG. 60.—Cerebral Hemispheres of Man and Chimpanzee dissected. *a*, posterior lobe; *b*, lateral ventricle; *c*, posterior cornu; *x*, hippocampus minor.

It had been seriously maintained by skilled anatomists that the ape had no posterior lobe (*a*), or posterior cornu (horn) (*c*), or small eminence in the floor of the posterior horn, called the hippocampus minor (*x*).

Huxley found them all, as anyone may see. Nay, more, he found these to be among the most constant parts of the ape's brain, and always in the same position as in the brain of man.

But after he had found them and shown them, some men continued to say they were not there!

They acted on the principle of the immortal Samuel Weller, when he truthfully declared that he could not see his father in court.

No scientific man denies that the brain of man is a higher structure differing widely from that of apes; but this great saying of Huxley's remains true unto this day: "So far as the brain is concerned, therefore, it is clear that man differs *less* from the chimpanzee or the orang than these do from monkeys, and that the difference between the brains of the chimpanzee and of man is almost insignificant when compared with the difference between the chimpanzee brain and that of a lemur."

It is well to remember that the brain is the most important organ of man; but it is better to remember that this same brain proves beyond doubt that apes and man are one family.

When speaking of apes and man, Professor Romanes said: "There is no bone, muscle, nerve, or vessel of any importance in one which is not answered to by the other. Hence there are hundreds of thousands of instances of the most detailed correspondence, without there being any instances to the contrary, if we pay due regard to vestigial characters. The entire corporeal structure of man is an exact anatomical copy of that which we find in the ape."

We may fitly close this reference to the brain by quoting Professor Ray Lankester's original photograph of the tops of skulls (Fig. 61). On the left is the skull of a chimpanzee, in the middle the skull of "the monkey-man" (Pithecanthropus, discovered in Java), on the right the skull of a modern man.

"A line is drawn from the point between the eyebrows to the occipital ridge at the back of the skull, showing how much shallower the dome of the skull (the part above the line) is in the ape than in the man, and that the Javanese skull is nearly as shallow as that of the ape."

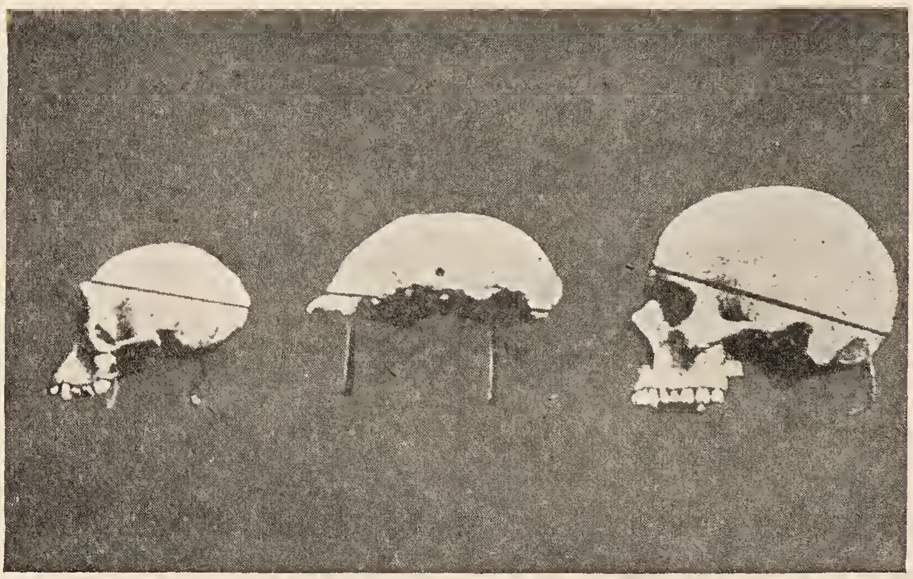


Fig. 61.—Comparison of the Tops of Skulls.

We may close this chapter with two or three examples of a somewhat lighter kind, but nevertheless very striking.

The crested bird (Fig. 62) does not seem very remarkable; but it is one of the most wonderful creatures in the world. This celebrated pheasant is a native of the Amazon valley. It haunts lagoons, creeks, rivers covered with thick growth of low trees or bushes. A strong musty odour is given off by the adults, so it is called the "stinking pheasant."

The whole history and structure of this bird have been more carefully studied than those of any human being. We ought to look on Fig. 63 with more than reverence. Mr. Pycraft, the great authority on birds, says: "In the wing of this nestling we have a revelation of profound importance, for, so it seems to me, through it we get a glimpse into the phylogeny, not only of its immediate allies (the Gallinae), common fowls, but possibly into that of the whole class of birds."

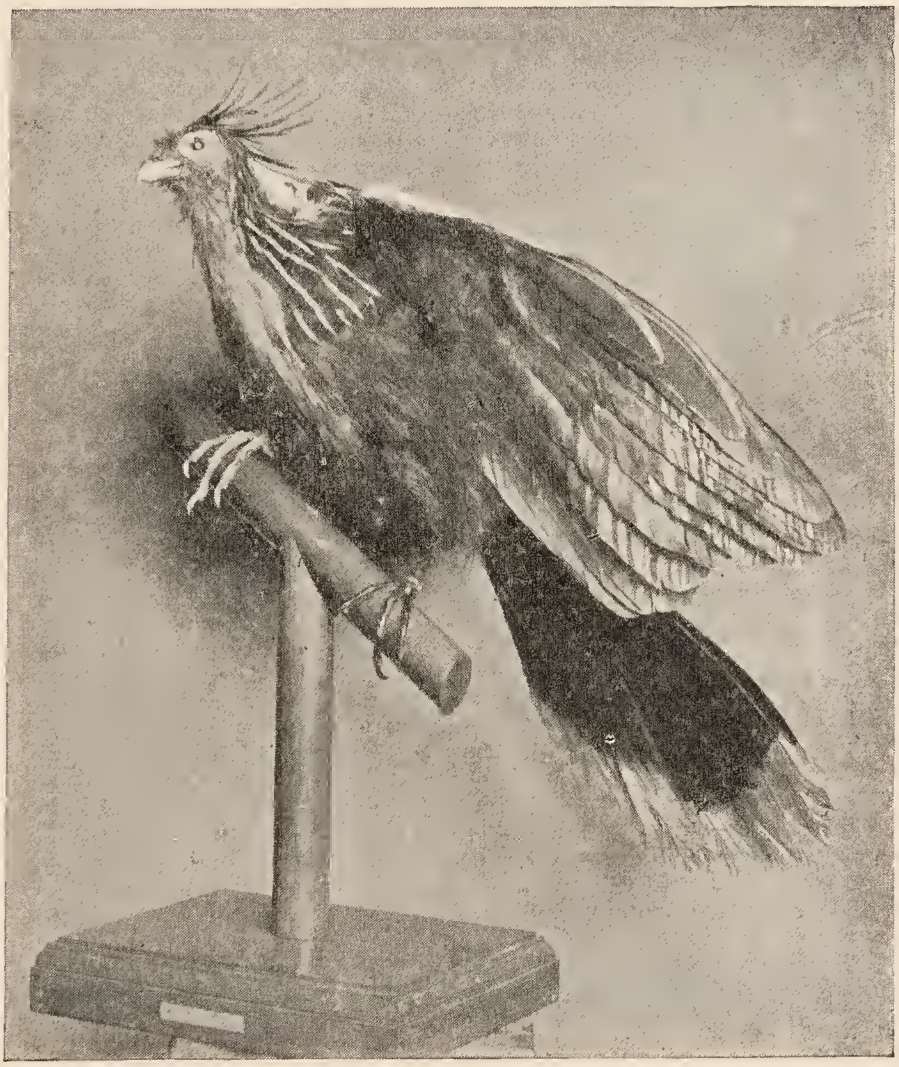
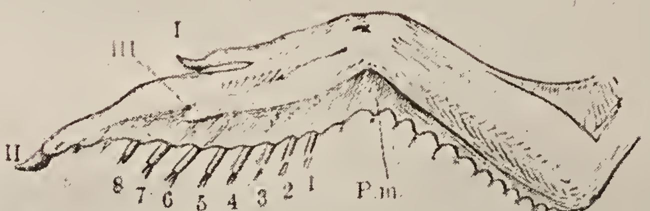


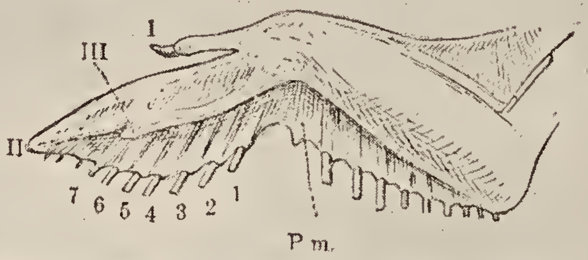
Fig. 62.—The Stinking Pheasant (Opisthocomus cristatus), also called the Hoatzin.

This bird lives in trees in the strictest sense, rarely, if ever, coming to the ground. The young can see and swim as soon as they are hatched.

The marvellous thing is that the young nestling uses its wings to assist it in climbing about the trees, for it does not remain in the nest till it is able to fly. The young bird possesses enormous feet fitted for grasping. It uses its beak very much as a parrot does to help in climbing; but when this young bird climbs it climbs with *four feet*, for there are two large claws, marked I. and II., on this wing, and by means of these claws the young bird climbs in a four-footed way. We might call it a quadruped. Cuvier's saying has proved to



The right wing of a nestling *Opisthocomus cristatus*, ventral view, showing how that the 2nd digit (II.) is produced beyond the ala membrana (P.m.), and that the development of remiges 8-10 has been arrested, so as not to interfere with the freedom of the long finger when climbing.



The right wing of a nestling of a Common Fowl (*Gallus bankiva*), an ally of *Opisthocomus*. Owing to the exchange of an arboreal for a terrestrial habit, the manus is gradually shortening. The pollex only retains the claw. The 2nd digit projects but slightly beyond the ala membrana; but the development of the most distal remiges is still arrested.

FIG. 63.—Wing of Young Hoatzin and Common Fowl.

be true; he declared birds were really four-legged animals.

Now, as the bird grows, the claws disappear; it gets its full wings and flies as a fully-developed bird. There is the great gratification in this example that we are neither talking of something under a microscope, which most people can never see, nor referring to some marvel of the rocks which lived millions of years ago. No! Here we have a living thing of the American forest, seen by living witnesses, studied by nearly every leading scientific zoologist, and proved to begin its life in this clumsy four-footed way, and in the course of a few weeks it has become a bird!

After the student has grasped the general principles of Evolution, few methods are better than to take some one organ—the eye, or ear, or brain—and learn its fullest history, both among animals and in the embryology of man. This method requires hard work, but it would effectively establish the doctrine of Evolution.

Another method, far easier, is to collect a few remarkable examples, such as the three toes of the fœtal foot (Fig. 86), the wing of the nestling "stinking pheasant" (Fig. 63), the comb on the bird's foot (Fig. 64). This last marvel is found developed on the foot of the common barn-owl, the night-jar or goat-sucker, and the heron and bittern species.

In Fig. 64 I. is the foot of the Night Heron.
II. is the foot of the Nightjar.

Many theories have been put forth to account for the comb on the claw; but, as all these are very lousy birds, probably its use is "to rid its plumage of parasites."

Perhaps we are entitled to a laugh, even in dealing with such a grand subject as the evolution of the crowning animal of the universe.

A short time ago an opponent of Evolution (a thing which clearly he did not at all understand) sent a tract to convert me from the error of my ways. It was an interesting product as a case of degeneration.

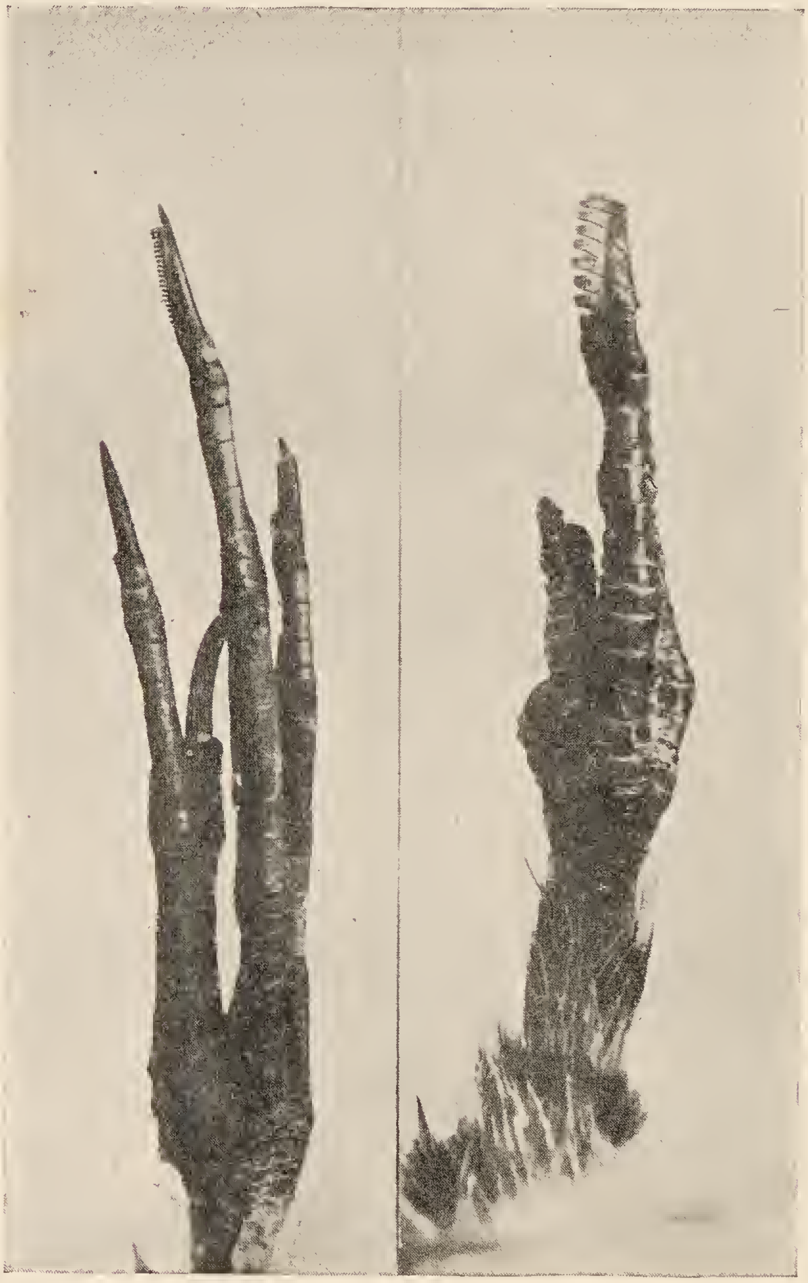


FIG. 64.—Combs grown on Feet of Birds.

The author had looked up Evolution in some popular encyclopædia, which *he* called a *dictionary*. Then came this illuminating inference :—

"Brother Grim thinks that IF he came from a TAD-POLE, and the Horse came from an Animal with Five Toes, Mrs. Grim must have come from a Fine Dorking Hen-pecker. As to the ridiculous question, Which came first? the Hen, or the Egg, he firmly believes the Hen comes first as well as last." (I have preserved the beauty of the original in every detail.) Then followed Fig. 65.

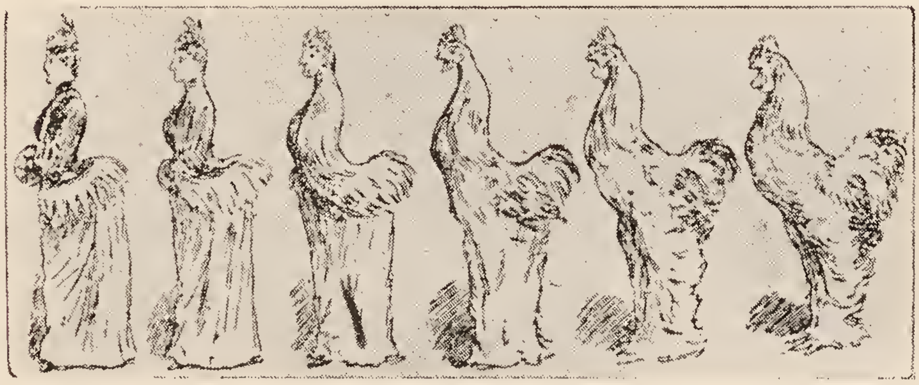


FIG. 65.—A comic cartoon showing its author's sublime fancy of the way in which a hen might develop into a woman.

It is never safe to illustrate a book, for often the letterpress says one thing and the picture another! In the case of this Grim joke it is unfortunate that Mr. Grim built his theory around the Dorking hen; but the picture knows nothing of the Dorking. It depends for its science (?) on a gigantic sort of *Brahma* hen. Probably "Brother Grim" did not know one from the other, and in this case all his knowledge of Evolution was on the same level.

Chapter III.

EMBRYOLOGY AND RUDIMENTS

We have such abundant evidence of the evolution of man that it has become difficult to give any fair idea of the mass of evidence in a small book.

In Part I. we saw some of the evidence from astronomy, which proves that this law of Evolution is not confined to living things. Next we were able to see from geology that there is a record of animals showing that many species have disappeared, that many species have altered in form, and that several species can be traced back to one ancestral group; in fact, that, as the rocks themselves have evolved, so have the animals whose skeletons they preserved. For there is always this uniform wonder—that, the further back we go into the history of the past as revealed by geology, the less are the oldest animals like our modern animals; and the older the skulls of men, the more do they resemble the ape family.

In zoology we saw again and again that it is quite impossible to draw a sharp line between one group of animals and another. In the last chapter we saw agreements of plan or structure which it seems impossible to explain on any supposition except that all animals have come by a long series of changes from some common ancestor.

Still, there is stronger positive evidence of Evolution in embryology than elsewhere. And such difficulties meet us, when we consider rudiments, that no explanation can possibly be given of them except that furnished by Evolution.

Embryology is the science which traces the growth of any animal, *before birth,* from a cell, about 120th of an inch in diameter, to its complete form, such as is seen when it is born.

Now, until science is taught to the children of the nation, it will be a very hard task to teach anything about embryology, for this reason alone—that it deals with very small objects at first, and with structures that can only be seen through a good microscope by one who has been trained.

One almost sinks in despair before such a difficulty. Here is a record of animal forms, and of likenesses between one animal and another, so marvellous that it surpasses the wonders of all fables and the mysterious beauty of all imagination. This history of animal growth is written millions of times in every country, in every year. Every animal, from the lowest to man, contributes its page to this revelation of the past, which is recorded in the facts of every new life. All animals grow from a single cell. The biggest, the most beautiful, the most intelligent—all begin in the same way, and, for a longer or shorter period, pass through exactly the same stages.

It is not a matter of imagination. Here, at any rate, "the man in the street"—that mystic umpire of the cosmic game—is brought face to face with an ever-recurring fact—the growth of the highest (himself!) from a single cell. He may call the explanation of the growth of all the families and tribes of earth, from monera or amœbæ, a paying bit of fiction, and he may object that no newspaper reporter was present to chronicle this brilliant drama, and therefore he rejects it as an explanation of the inhabitants of the world. But a greater miracle meets him on his own door-step—himself. He was once virtually a single-celled amœba.

As Dr. Saleeby says in his excellent little book, *Organic Evolution:* "The greatest of men—your Aristotle or Shakespeare—began his individual career as a unicellular organism just visible, in a good light, to the naked eye. This minute creature has neither organs, nor parts, nor passions, nor ideas. Yet in nine months it becomes a baby, and twenty-seven years later it may write a *Romeo and Juliet,* or be founding a new religion. Had we seen for ourselves the æonian evolution of man from the primitive slime, but never witnessed the relatively instantaneous development of a man from a human germ, we might well account the latter impossible. But, having seen the greater marvel, we cannot call the lesser incredible."

In order, then, to try and understand some of these facts of such wonder and beauty, we will begin with a few of the lowest forms of life.

Tradescantia (Fig. 66) is the common Virginian spiderwort, and the nucleus is the one large, round, dark-coloured body. This piece of plant is largely magnified, for it is only a hair-cell. The little bodies at *b* and *c* are also formed of protoplasm.

In Chapter V. of *An Easy Outline of Evolution* I have given an account of protoplasm. It there states: "The substance is a semi-transparent, grayish material, looking like thin gum, into which transparent granules have been stirred. The substance which has this appearance is protoplasm, and *is the living part of the cells of all animals and plants.*"

We must bear in mind that protoplasm is a living substance—as much a living thing as a cow or a child. It shows all the chief characteristics of all living animals.

The bacteria (Fig. 67) are shown not to induce anyone to study them, or because they are any help directly in studying Evolution, but because they are so commonly abundant and so small. It took man thousands of years to discover them. They grow so very rapidly in certain preparations that, if one small drop were taken, a million bacteria might easily be present in it.

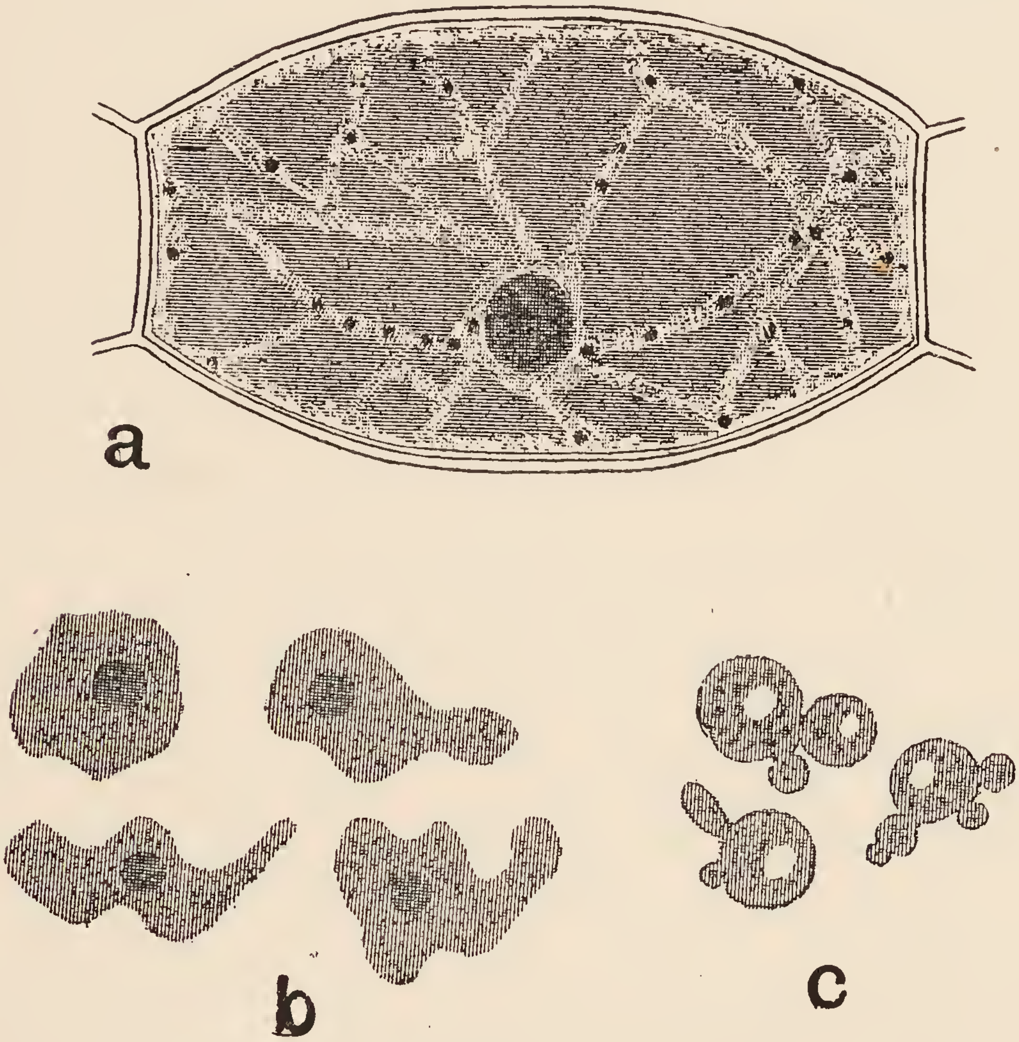


FIG. 66.—*a*, Cell from filament of Tradescantia. The protoplasmic threads are light, and in them are contained the nucleus and chlorophyll granules. The spaces between the threads are filled by coloured cell-sap. *b*, a white or amœboid corpuscle from the blood of a frog, showing changes of shape undergone during five minutes; *c*, group of yeast-cells, exhibiting active budding. (After *Mitchell.*)

They are also called bacilli or microbes. They are found almost everywhere; they are the causes of many diseases, and when milk or meat, etc., "goes bad," they are the cause of that, too. Small as they are, you see from this figure that very many shapes are known and named.

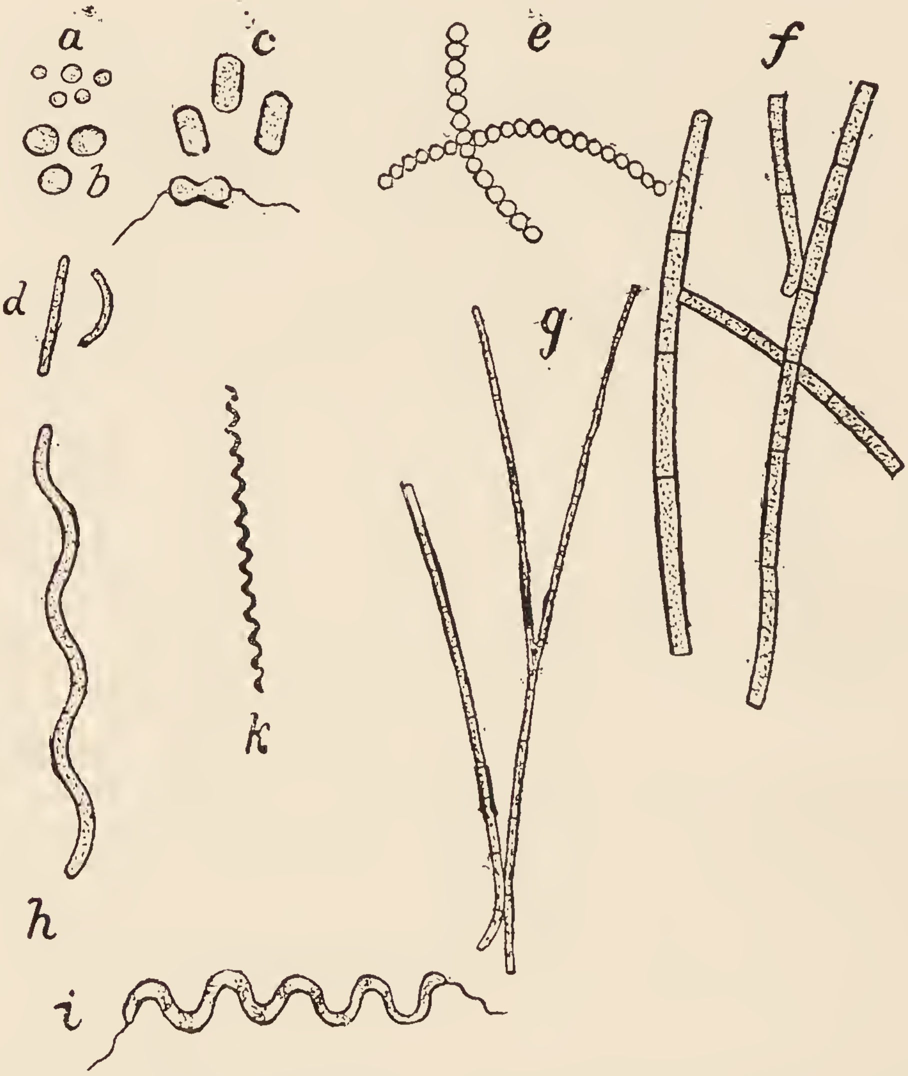


FIG. 67.—Forms of Bacteria. *a,* micrococci; *b,* macrococci; *c,* bacteria; *d,* bacilli; *e,* streptococci; *f,* septothrix; *g,* cladothrix; *h,* vibrio; *i,* spirillum; *k,* spirochaete.

They are much smaller than one ten-thousandth part of an inch.

I have given these very fine specimens of the amœba (Fig. 68) because it is of such great value in helping us to understand all the lower forms of life, and the first steps in all embryology. The

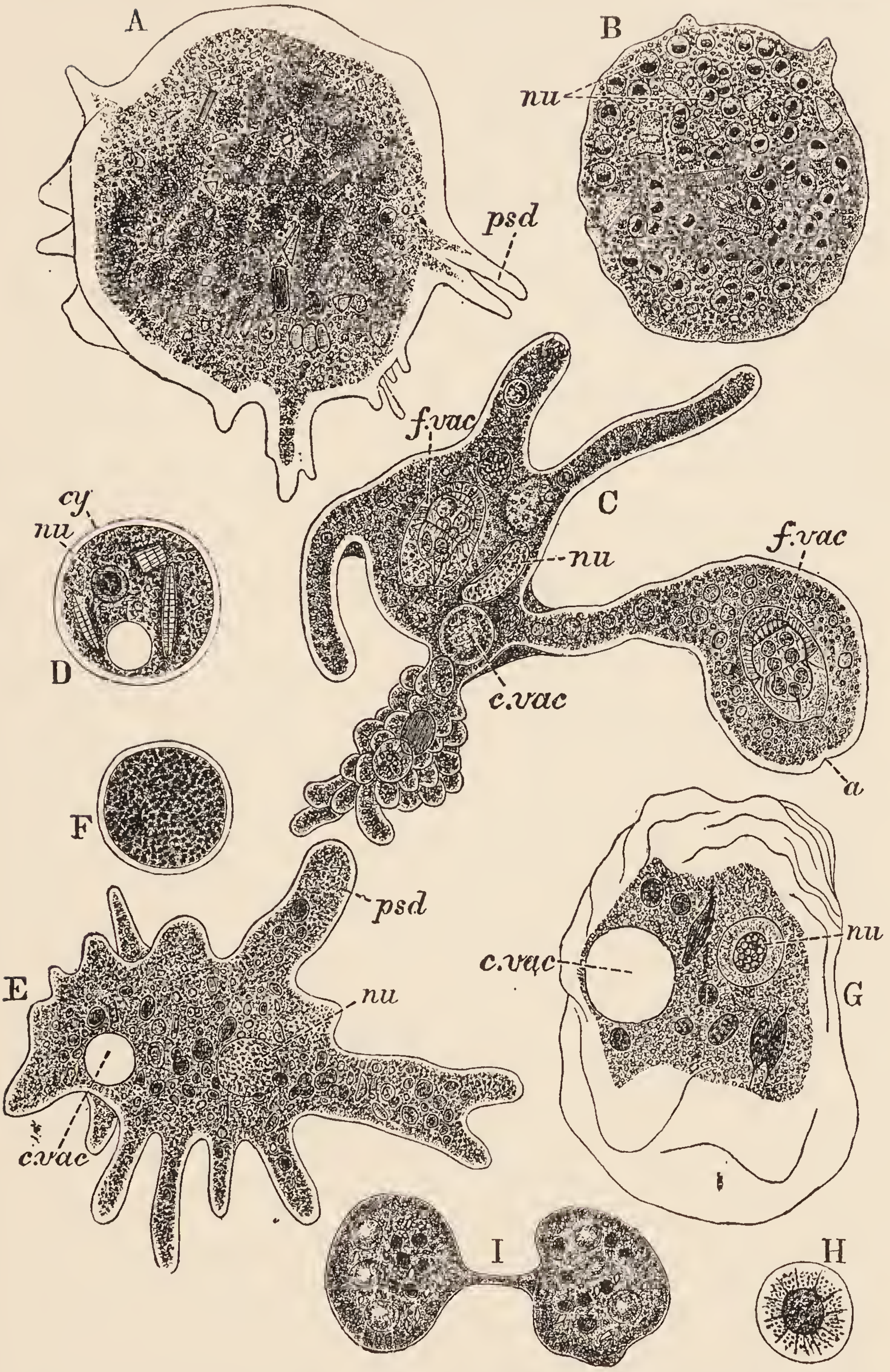

A
B
nu
psd
f.vac
C
cy
nu
nu
f.vac
D
c.vac
a
F
psd
c.vac
nu
E
nu
G
c.vac
I
H

FIG. 68.—The Amœba. A, Amœba quarta, a living specimen, showing granular endosarc surrounded by clear ectosarc and several pseudopods *(psd)*, some formed of ectosarc only, others containing a core of endosarc. The larger bodies are mostly food-particles. This is enlarged 300 diameters. B, The same species killed and stained with carmine to show the numerous

nuclei (*nu*). C, Amœba proteus, a living specimen, showing large irregular pseudopods, nucleus (*nu*), contractile vacuole (*c.vac*), and two food vacuoles (*f.vac*), each containing a small infusor which has been taken as food. The letter *a* to the right of the figure indicates the place where the protoplasm has united round the prey to enclose the food vacuole. D, An encysted amœba showing cell-wall or cyst (*cy*), nucleus (*nu*), clear contractile vacuole, and three diatoms ingested as food. E, Amœba proteus, a living specimen, showing several large pseudopods (*psd*), single nucleus (*nu*), and contractile vacuole (*c.vac*), and numerous food particles. Enlarged 330 diameters. F, Nucleus of the same after staining, showing deeply-stained granules of chromatin, surrounded by a distinct membrane. Enlarged 1,010 diameters. G, Amœba verrucosa, living specimen, showing wrinkled surface, nucleus (*nu*), large contractile vacuole (*c.vac*), and usual ingested organisms. Enlarged 330 diameters. H, Nucleus of the same, stained, showing chromatin aggregated in the centre to form a nucleolus. Enlarged 1,010 diameters. I, Amœba proteus, in the act of multiplying by binary fission. Enlarged 500 diameters. (From *E. J. Parker.*)

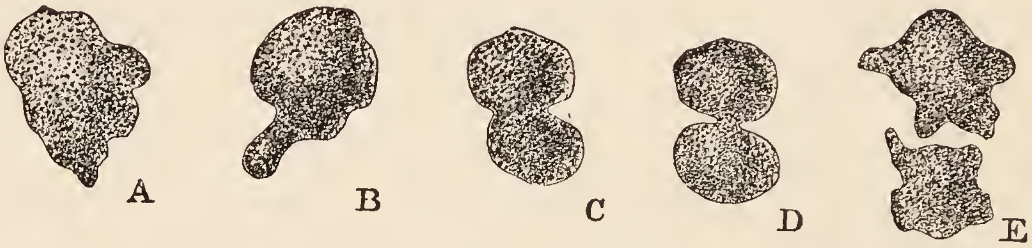


FIG. 69.—Protamœba Primitiva. A, B, the same specimen drawn at short intervals, showing changes of form; C, D, E, three stages in the process of binary division. (After *Haeckel.*)

amœba is easily found in stagnant water, but it seldom exceeds one-hundredth part of an inch, so it is mostly invisible to the naked eye. It seems to be a little shapeless blob of jelly, nearly or quite colourless. This jelly is protoplasm. Amœba means the changing one, and it is so called because it is never the same shape for long together, for it is always pushing out some parts and drawing in others, which in the figure are marked pseudopods—*i.e.*, false feet.

Occasionally amœbæ—or, more strictly, amœba-like organisms—are met with which have neither nucleus nor contractile vacuole, and are therefore placed in a separate genus, protamœba (Fig. 69).

They may be looked upon as the simplest of living animals. Haeckel calls this animal a moner, and sometimes a zoomoner, to distinguish it from a vegetable moner, which he calls phytomoner.

[These two words are from *zoon,* animal, and *phyton,* plant; *monērēs* (plural, *monera*) single.]

For vegetable monera see Figs. 8 and 100.

The monera differ from the nucleated amœbæ in the fact that "they are unnucleated cytodes, the body of which consists of only *one kind* of albuminous matter—the homogeneous plasson or 'formative matter'"; whereas the later and higher stage are nucleated cells, and the original plasson is divided into two formative substances—the caryoplasm of the nucleus and the cytoplasm of the body of the cell.

The haematococcus (sometimes called protococcus) (Fig. 70) is found in rain-water, in puddles or gutters, of a green or red colour. The colour is due to the presence of small organisms of which the haematococcus is the commonest. Like the amœba, it requires to be magnified some 900 times in order to be seen.

The haematococcus is interesting because it is impossible to determine whether it is a plant or an animal.

If this figure is compared with that of the amœba, many points of resemblance will be seen; but the cell-wall of amœba is probably nitrogenous, whereas this creature has its cell-wall formed of a carbohydrate called cellulose, allied in composition to starch, sugar, gum.

We should note that in amœba contraction is performed by the whole body, in haematococcus it is performed by a small part only—the flagella; we have, therefore, here a *differentiation of structure* accompanied by a differentiation of function, or division of physiological labour.

The springing monad (Fig. 71) is much smaller than amœba or haematococcus, being only $\frac{1}{3000}$th of an inch ($\frac{1}{120}$th *m.m.*) in length. It presents points of advance; it has distinctly a posterior and anterior end; also a ventral and dorsal surface. It is not entirely a vegetable or animal. It not only reproduces by simple fission like the amœba, but in E^1 we see the two posterior ends coming in contact till they become one cell in E^2. There is

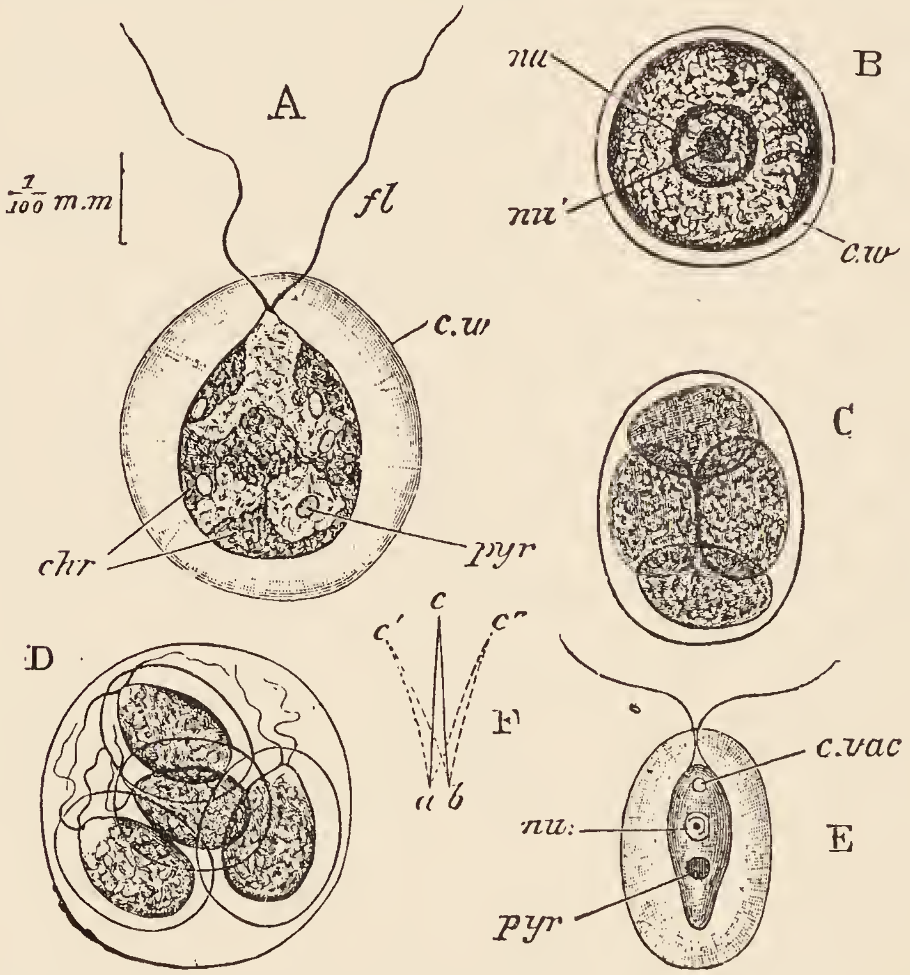
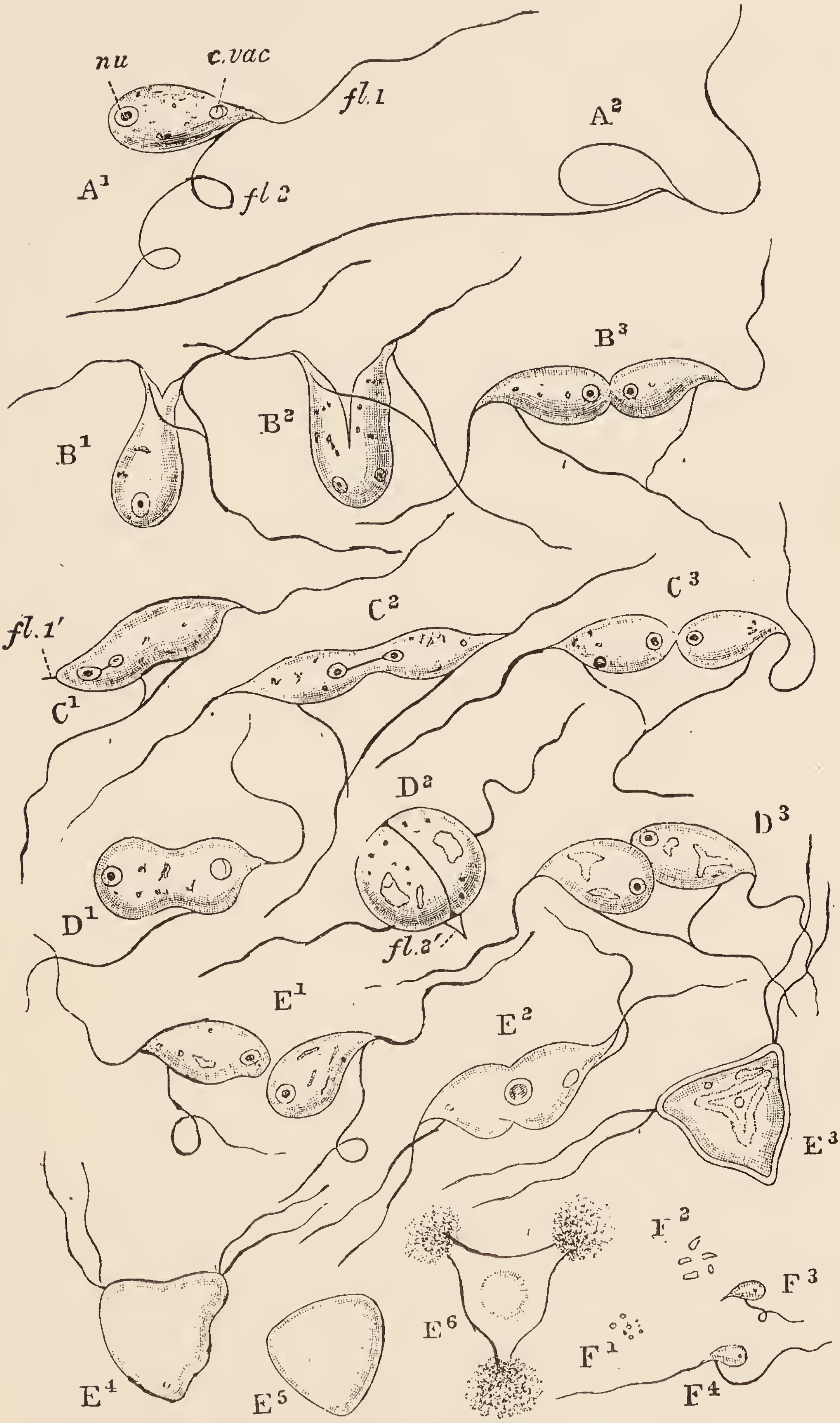


Fig. 70.—A, Haematococcus Pluvialis, mobile phase. Living specimen, showing protoplasm with chromatophores *(chr)*, and pyrenoids *(pyr)*, cell-wall *(cw)*, connected to cell-body by protoplasmic filaments, and flagella *(fl)*. The scale of measurement to the left applies to Figs. A, B, C, D. B, resting stage of the same; C, the same, showing division of the cell-body into four daughter-cells; D, showing development of flagella before daughter-cells are liberated; E, haematococcus lacustris.


nu
c.vac
fl.1
A¹
fl 2
A²
B¹
B²
B³
fl.1'
C¹
C²
C³
D¹
D²
fl.2'
D³
E¹
E²
E³
E⁴
E⁵
E⁶
F¹
F²
F³
F⁴

[For description see next page, Fig. 71.

FIG. 71.—The Springing Monad, Heteromita Rostrata. A^1, living organism ; *fl*^{2}, the coiled ventral flagellum by which the organism is anchored ; A^2 shows the position at the forward limit of the spring, *fl*^{2} being fully extended ; B^1–B^3, stages of fission, longitudinally, of the anchored form ; C^1–C^3, stages of fission, transversely, of same ; D^1–D^3, fission of the free swimming form ; E^1, free swimming and anchored forms about to conjugate, till process is complete in E^5 ; E^6, the emission of spores ; F^1–F^4, stages in the development of the spores. (After *Dallinger.*)

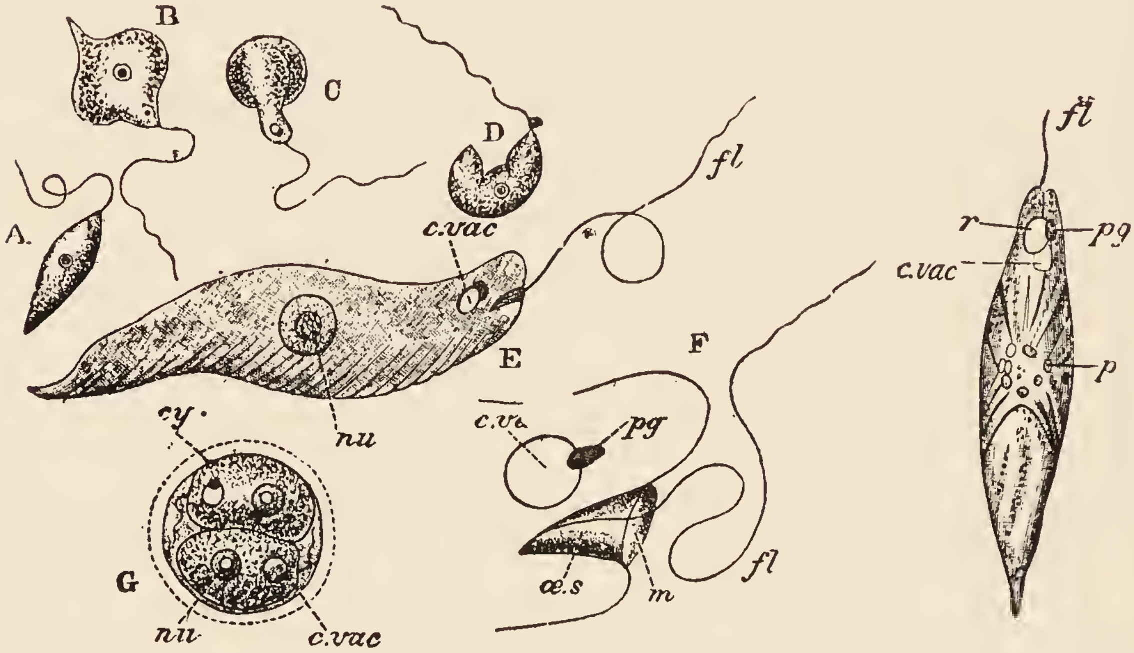


FIG. 72.—Euglena Viridis. A–D, living organisms, showing changes of form ; E, enlarged view ; F, enlarged view of *anterior* end, showing pigment spot *(pg)*, mouth *(m)*, gullet *(œs)* ; G, resting form after fission ; H, active form. (From *Parker.*)

no clear distinction of sex; but perhaps the free swimming monad may be considered as the male, and the passive anchored form as the female.

Note the most important fact : "The spores, F^1, are mere granules of protoplasm, approaching as nearly as anything in nature to the mathematical definition of a point, 'without parts and without magnitude.'"

In this monad we have our first instance of development, since in simple fission there is no development, each product of division being, from the first, similar to the parent in all but size.

Here, also, is the first instance we have had of an organism with a definite life-history.

The Euglena (Fig. 72) is larger than the last two creatures. The body consists of protoplasm covered with a very delicate skin or cuticle. It is

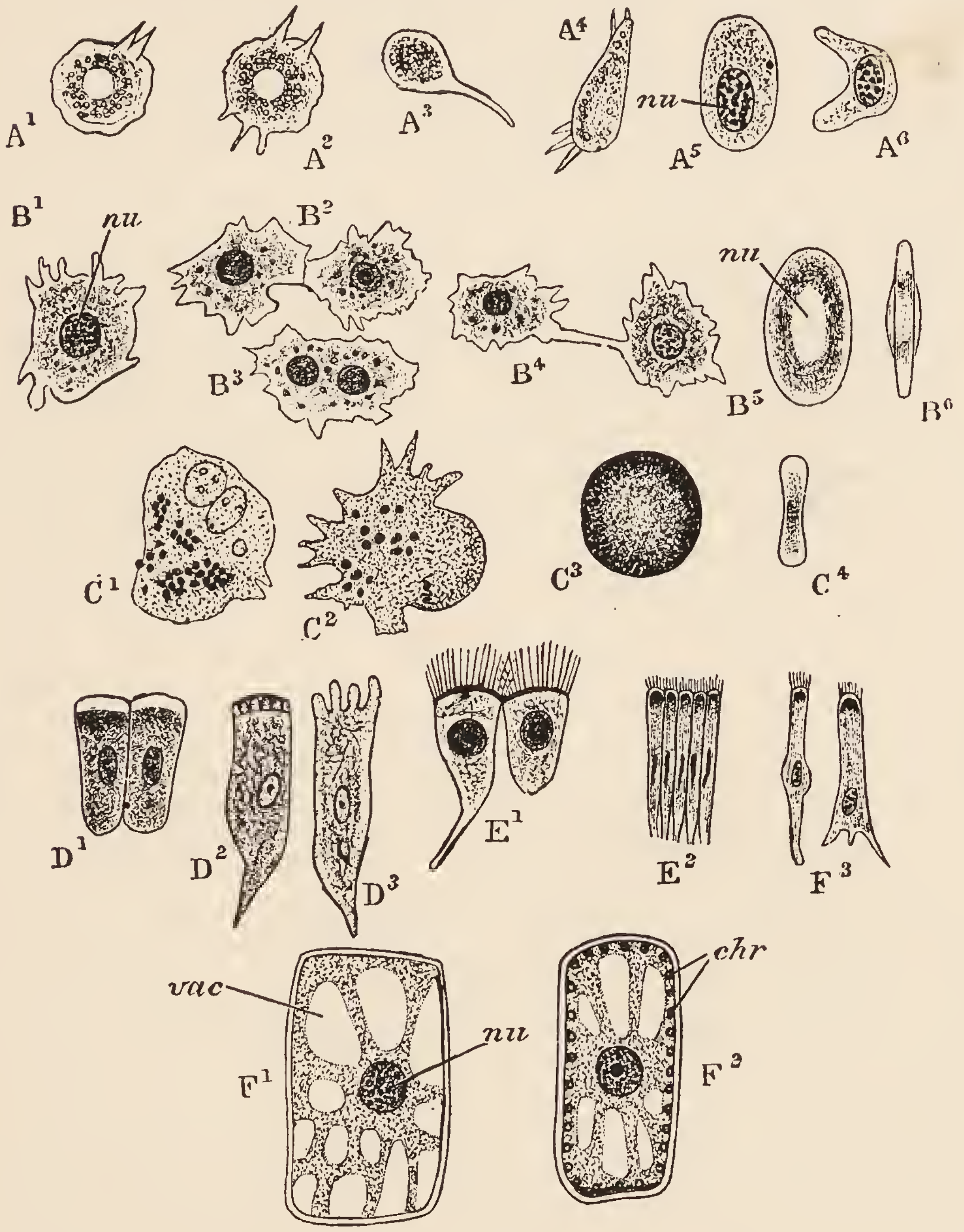


FIG. 73.—Typical Animal and Vegetable Cells. A^1–A^2, living leuco-cytes (blood corpuscles) of a crayfish. B^1–B^4, the same of a frog; B^5 and B^6, surface view and edge view of a red corpuscle of frog; C^1, C^2, leucocytes of newt (the black dots are particles of vermilion which have been ingested); C^3, C^4, surface and edge view of red corpuscle of man; all D and E are epithelial cells from intestines or mouths of animals; F^1, cell from root of lily; F^2, from leaf of a bean. (From *Parker.*)

partly animal and partly vegetable. It seems to feed like a plant in the daylight, and like an animal in the dark.

These typical cells (Fig. 73) are not given that all their names may be learnt, but that the varieties of form and the similarity of the material may be seen. These cells are again instances of protoplasm with a nucleus, though they are from man, frog, crayfish, or root of a plant.

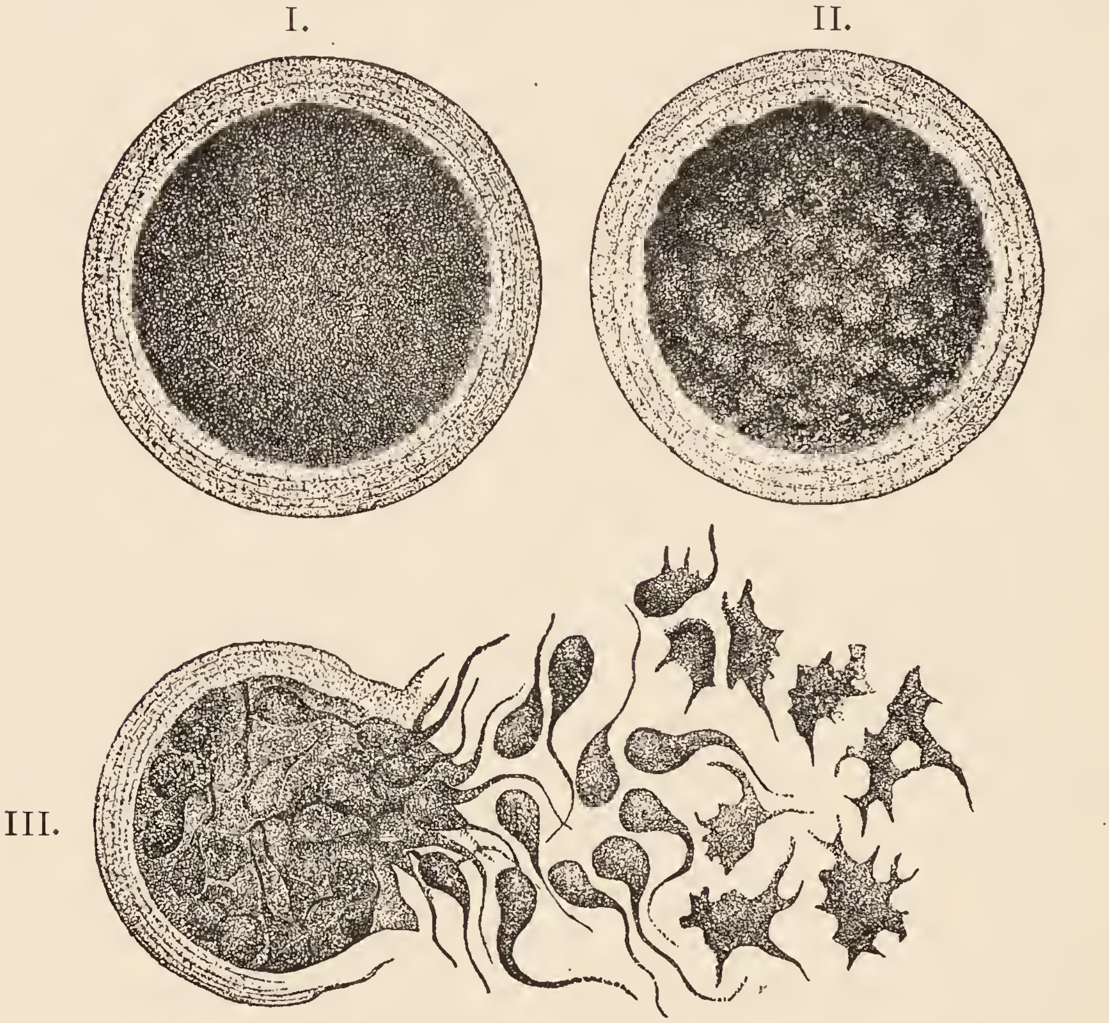


FIG. 74.—The Protomyxa, one of the primitive moulds, or Myxomycetes. I. and II. show it encysted: in II. we see its division into numerous individuals within the cyst; III., the cyst bursts, the flagellate young rush out like so many minute tadpoles, but at once they become like amœbæ, as seen on the right. (After *Geddes* and *Thomson.*)

"We come, therefore, to a very remarkable result. The higher animals and plants are built up—in part, at least—of elements which resemble in their essential features the minute and lowly organisms already studied in this chapter."

We may now begin to consider the sex cells, with a view to understanding the origin and growth of the higher animals.

The protomyxa (Fig. 74) is a good example of the three conditions of cell life: I., the passive (encysted); II., the active or ciliated (tadpoles); III., the amœboid. (See diagrams, Fig. 75.)

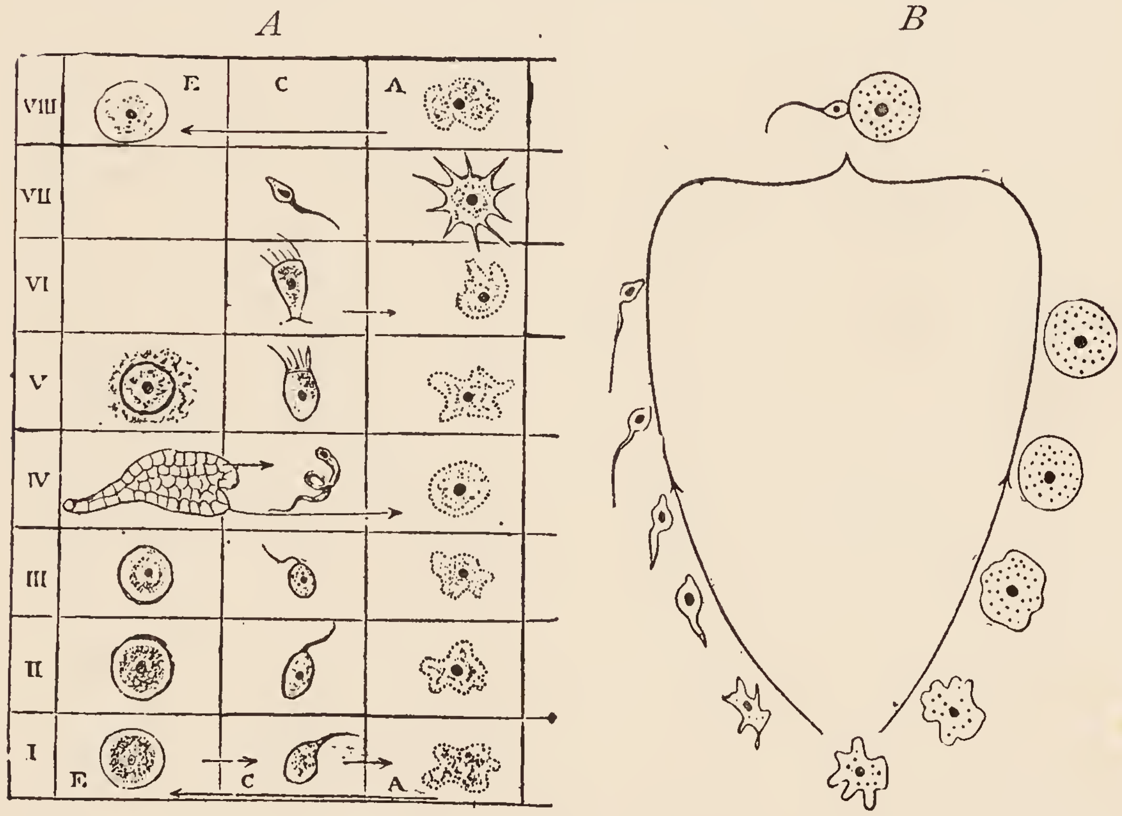


FIG. 75.—The Cell Cycle of Three Phases. *A*—E, encysted; C, ciliated; A, amœboid; I., II., and III. are protozoa; IV., ovum and sperm of fern prothallus; V., animal cells; VI., a ciliated animal cell pathologically becoming amœboid; VII., sperm and amœboid sperm; VIII., amœboid and encysted ovum. (From *Geddes.*) *B*—Diagram showing how the ovum and spermatozoon gradually diverge from an undifferentiated amœboid type of cell, the one at the bottom.

These are important distinctions, and hard names are used to indicate them. Taking them again in order:—

1. The passive cells show conservative accumulation; they grow, they build up; and the

physiological name for this process is Anabolism.

2. The active (ciliated) cells show a lavish expenditure of energy; they are disruptive: this process is Katabolism.

3. The amœboid cells take a sort of middle course; they compromise, as it were, between extreme Anabolism and extreme Katabolism.

Anabolism stands for self-maintaining functions —is individual.

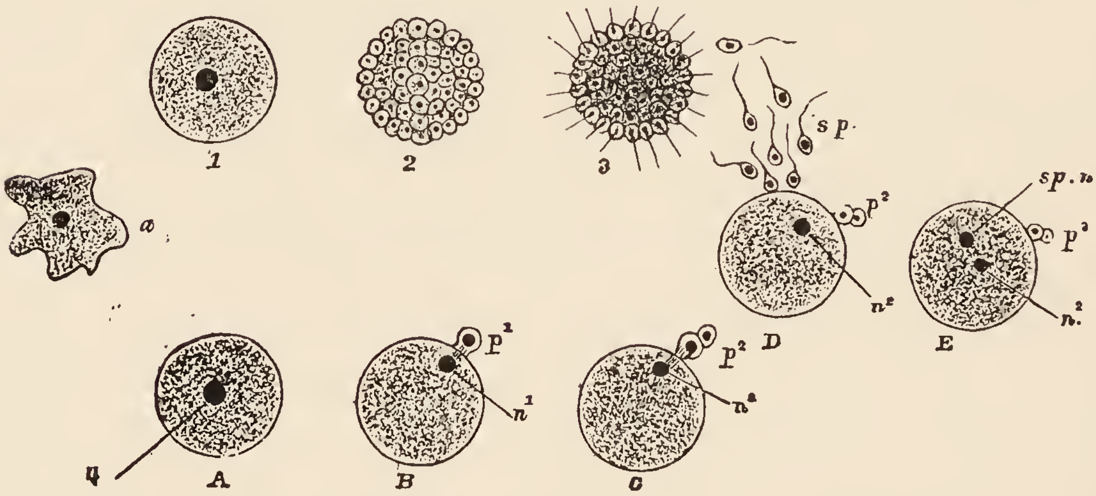


FIG. 76.—Fertilisation. The diagram shows the development of spermatozoa in the upper line, the maturation and fertilisation of the ovum in lower line. *a,* an amœboid sex-cell; A, ovum with germinal vesicle *(n)*; B, ovum pushing out first polar body, p^1, and leaving nucleus, n^1, reduced by half; C, extension of second polar body, p^2, nucleus, n^2, now reduced to one-fourth of original; *1,* a mother sperm-cell; *2,* dividing into immature sperms; *3,* dividing into mature sperms, *sp*; D, the entrance of a sperm into the ovum—note only one enters, as a rule; E, the male nucleus, *s.pn,* approaches the female nucleus, n^2. When these two nuclei unite, fertilisation has taken place. (After *Geddes and Thomson.*)

Katabolism stands for species-maintaining—is reproductive.

So femaleness is anabolic preponderance in reproduction; maleness is katabolic preponderance in the sperms.

The whole of this question requires much thought, and should first of all be read up in *The Evolution of Sex*, by Geddes and Thomson.

"The ovum, or egg-cell, is nearly identical in all animals, whether vertebrate or invertebrate. Considered as a cell, it is of large size; but, actually, it is not more than $\frac{1}{100}$th, and may be less than $\frac{1}{200}$th, of an inch in diameter. In man, as in most mammals, it is about $\frac{1}{120}$th of an inch. It is a more or less spherical body, presenting a thin transparent envelope, called the zona pellucida, which contains—first, the protoplasmic cell-substance, or 'yolk,' within which it lies; second, the nucleus, or germinal vesicle, within which lies, third, the nucleolus or germinal spot. This description is true of the egg-cells (ova) of all animals, if we add that in the case of the lowest animals—such as sponges, etc.—there is no enveloping membrane."

We may now look at the egg-cells (ova) of several animals (Fig. 77).

In Fig. 77 we see egg-cells from quite different animals, and it is only necessary to glance at them to see that the general arrangement is the same; and when we remember that these egg-cells, if fertilised, become the beginning of new creatures so widely different as a sponge and a cat, surely few things could be more interesting than this glimpse into the unity of all forms of living things.

We have the human ovum (Fig. 78) so greatly enlarged that even this does not give a clear view of its most important feature, for this does not show how small it is. To realise this, take a piece of paper exactly one inch long, and as narrow as it can be cut; on this slip make 120 circles, with a dot (nucleus) in every one of them, and a smaller dot (nucleolus) inside the dot. It will not, of course, be accurate, but it will reveal the minuteness of the egg-cell (ovum).

Now, if the egg-cell be so small, what must be the size of the nucleus? And it is this nucleus which is the beginning of the new life.

But *not* the whole of the nucleus. We have seen (Fig. 76) that the nucleus divides and pushes out one-half (a polar body), then divides again and pushes out a-half (second polar body), so that

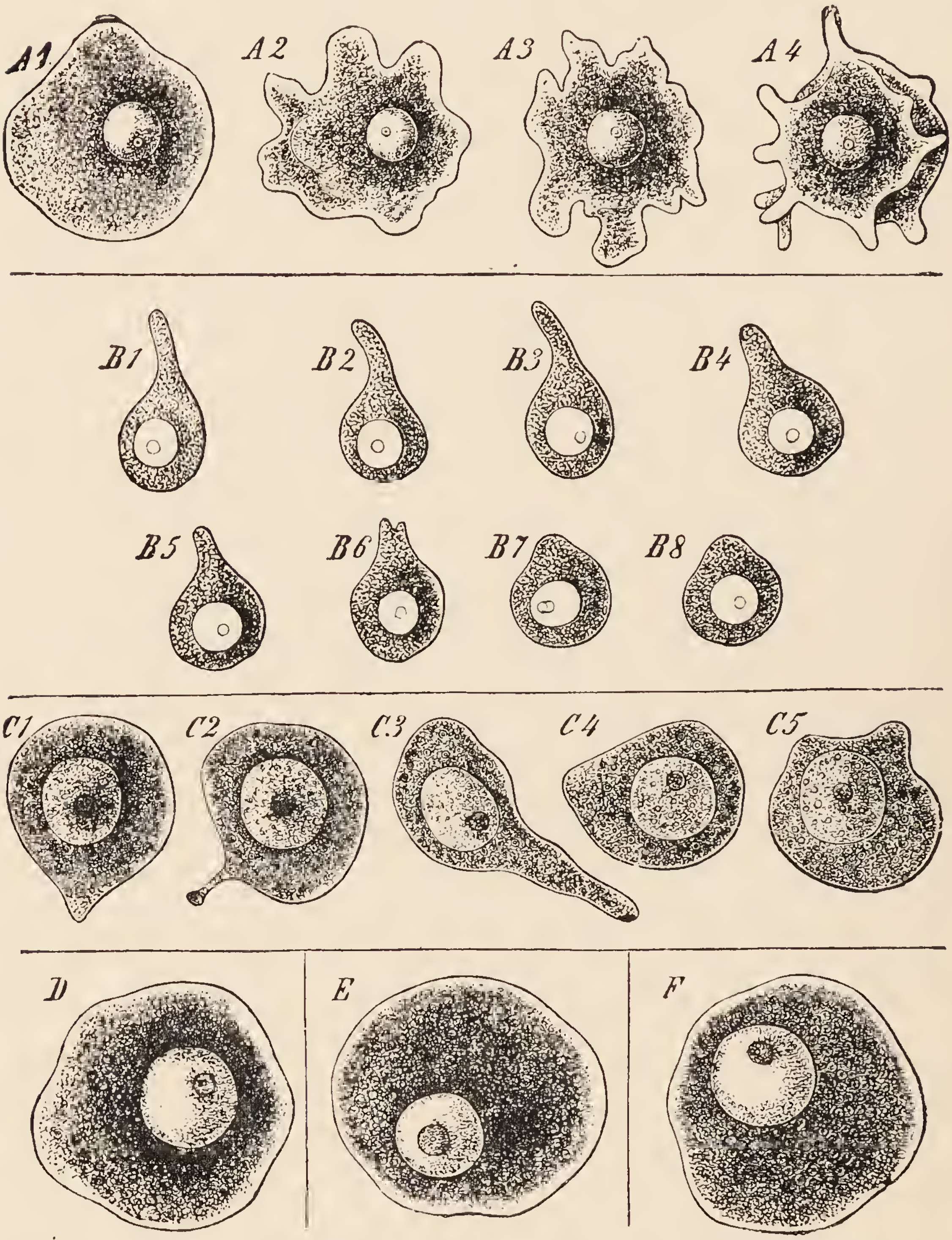

A1
A2
A3
A4
B1
B2
B3
B4
B5
B6
B7
B8
C1
C2
C3
C4
C5
D
E
F

FIG. 77.—Egg-cells. A^1–A^4, of the chalk sponge; B^1–B^8, of a hermit crab; C^1–C^5, of a cat; D, of a trout; E, of a hen; F, of man.

we have only a quarter of the nucleus as the beginning of the life of a new creature.

Now, this quarter of a nucleus contains two small bodies, the chromosomes. These two chromosomes united to two chromosomes of the male sperm form the fertilised cell, which is the beginning of the life of each animal above the lowest (the unicellular or protozoa).

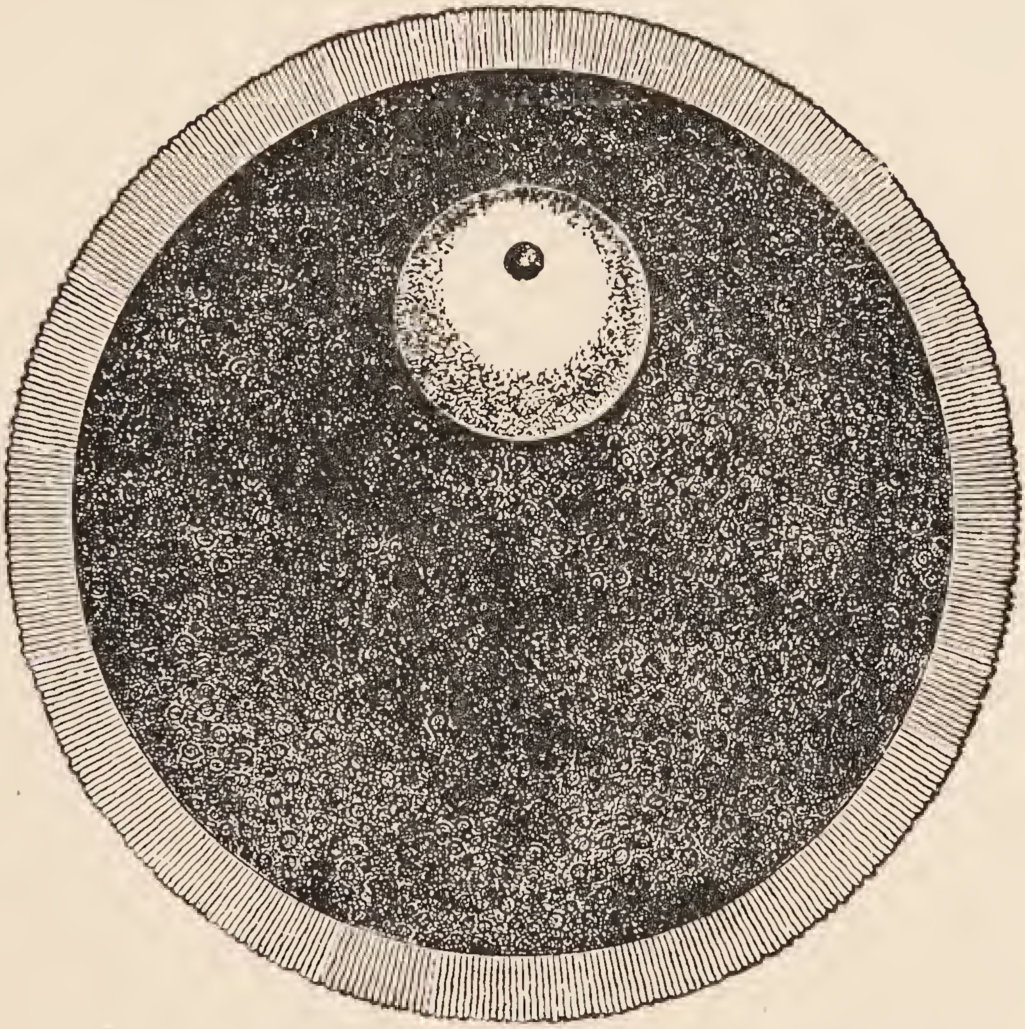


FIG. 78.—Human Ovum, mature and greatly magnified.

Now, if you work this out arithmetically, on the supposition that the two chromosomes fill half the space of the remaining quarter of the nucleus, you will find that it would take about 7,500 female chromosomes to make an inch. *N.B.*—The male chromosomes are smaller than the female!

Yet these chromosomes convey the form, features, and characters of the parents to the offspring.

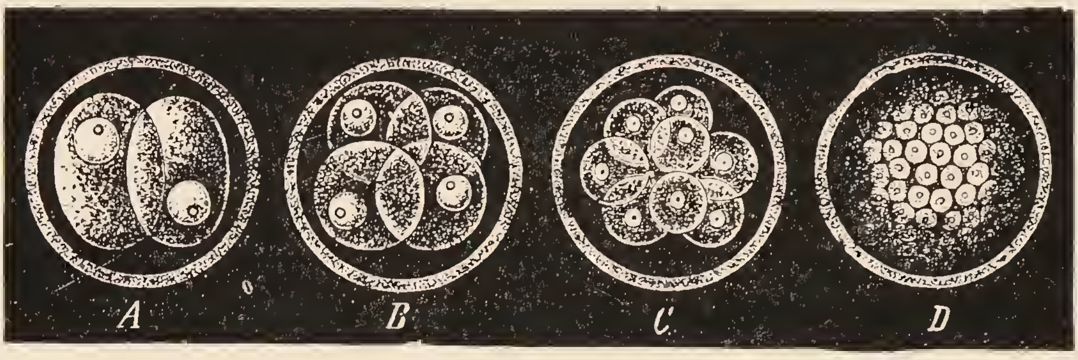


FIG. 79.—Cleavage or Segmentation of the Fertilised Egg-cell.

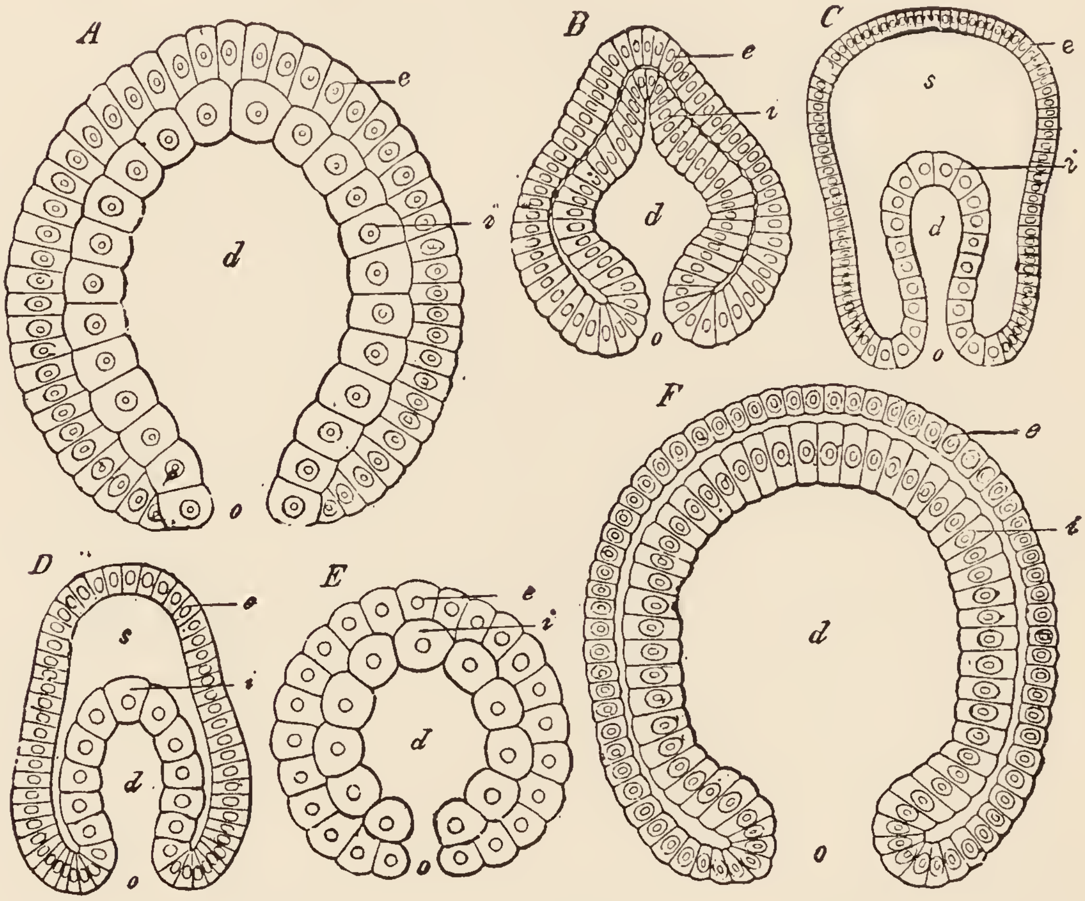


FIG. 80.—Gastrulation. *A*, gastrula of a zoophyte (gastrophysema); *B*, of a worm (sagitta); *C*, of an echinoderm (uraster); *D*, of arthropod (nauplius); *E*, of a mollusk (linnæus); *F*, of a vertebrate (amphioxus); *d*, the intestinal cavity; *o*, primitive mouth; *s*, the cleavage cavity; *i*, the endoderm or intestinal layer; *e*, the ectoderm or skin layer.

The fertilised egg-cell (Fig. 79), then, follows the law of all cell-growth. It divides into 2, 4, 8, 16.

After the four-cell stage the embryo is a solid mass of cells. The sixteen-cell stage is called the morula, because of its likeness to a mulberry; and may be compared to the moræa, or simple colony of protozoa.

The cells of the morula multiply rapidly, by division as before, and give rise to a *hollow* sphere, with a single layer of cells. This is the blastosphere, the cavity of which is called the *segmentation cavity*.

The next stage consists in the assumption of a cœlenterate or two-layered type. This takes place by the larger cells moving inwards to form the inner layer.

If you took a hollow guttapercha ball, and pricked it so as to let out the air, then pushed in one half upon the other, there would be half a ball, with *two layers,* instead of a whole ball with one. This would give a general idea of what happens when the process of invagination takes place, and two rows of cells are formed. There are several examples of this in Fig. 80, and up to this stage we are studying the *common* life-history of animals, from a lowly plant-animal (zoophyte, No. A) to a vertebrate.

This horseshoe-like arrangement is called gastrulation.

After this step, the next process varies a little in different animals, the first and most important being the appearance of a third (middle) layer between the original two.

In order to follow the development of the various types, it would be necessary to read up some handbook on embryology.

We have now done what is necessary for us—*viz.*, we have seen how animals begin to grow, how remarkably alike they are; and if they had not a common origin, we are left with this difficulty—Why do they all begin in this way?

To trace the further detailed development, it is best to take some book on elementary biology, and see the full life-history of a few typical animals. It may help to fix some of the lessons from the growth of these low forms if we carefully study the growth of a polyp (Fig. 81). Together with this, Fig. 99, Part I., should be most carefully noted.

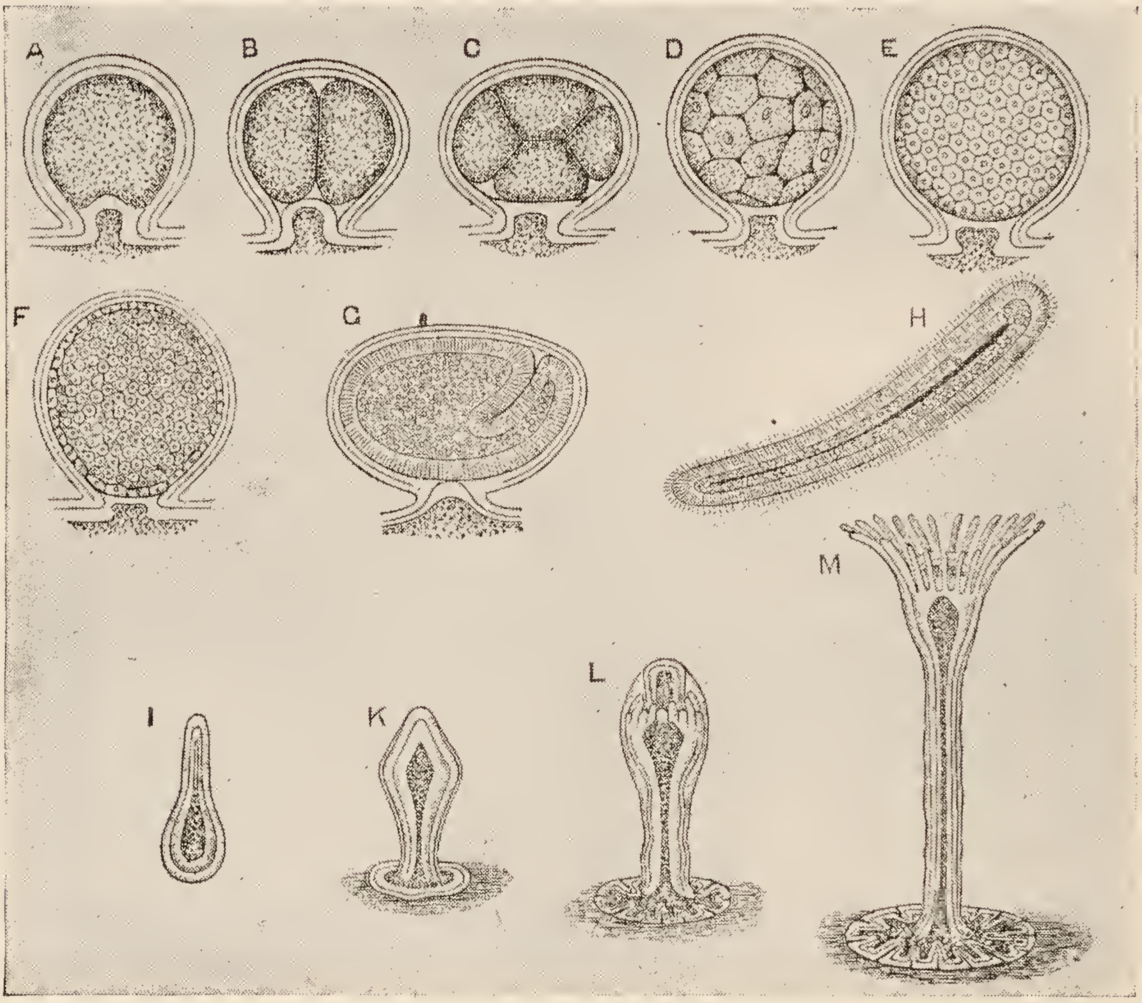


Fig. 81.—Stages in the development of the plant-animal, a hydroid polyp. A, oasperm; B, two-celled, and C, four-celled stage; D, E, polyplast; F, G, formation of planula by differentiation of octoderm and endoderm. In A to G the embryo is embedded in the maternal tissues. H, free swimming planula, showing ciliated ectoderm, and endoderm enclosing a narrow enteric cavity; I, planula after loss of its cilia, about to affix itself; K, the same after fixation; L, hydra-like stage, still enclosed in cuticle; M, the same after rupture of the cuticle and liberation of the tentacles.

It is difficult to exaggerate the importance of these early forms and small creatures, if we wish to be clear in our ideas of growth and look into such questions as "the origin of life."

In Fig. 81 we may see the mode of growth of living things. A is the cell as it is enclosed in the body of the parent; B shows that it is divided by fission into two parts. Next each part divides again into two, and this process is repeated, as in all embryos, till we have 2, 4, 8, 16 cells, at last forming a globular mass, as seen in D and E. This stage E is the morula (mulberry). In F we see the cells are becoming unlike—that is, the outer are differentiated from the inner. Next, in G, the embryo begins to change its form and to show slow movement, finally escaping from the parent, and beginning a free existence, as seen in H. Observe the black line running the whole length of the body, H. This should be interesting to some people because it is the first appearance of digestive activity—the origin of that prime and everlasting ruler of the earth, the Stomach.

The bottom row of figures shows the various stages through which H passes before it becomes fixed and a full-grown hydra. Such is the history of this universal process by which a body is formed from a single cell; and with a little reflection and an average imagination it should be possible from this figure to obtain some fairly clear notion of the growth of bodies, including our own.

In the features actually discovered in the young growing organism (embryo) anyone may trace the likeness to very remote ancestors.

For instance, gills are well-known in fish; but no one thinks of a dog or cat or baby as having gills.

Fig. 82 shows the gills of an adult fish. Now, if we take gills and look for their origin, we have to go back, not only to the earliest forms of fish, but even to a low animal such as the acorn-worm (Fig. 83, I.). The line of light-coloured loops beginning nearly opposite K are the gill-slits. (See Fig. 101, Part I.) Again, in Fig. 83, II., we see in the sea lamprey, just behind the eye, seven gill-slits; also in the shark (Fig. 83, III.) we see the gill-slits. Now, all these were present *before* the gills *were* developed in any animal.

Gills and gill-slits are of the utmost importance in our family history.

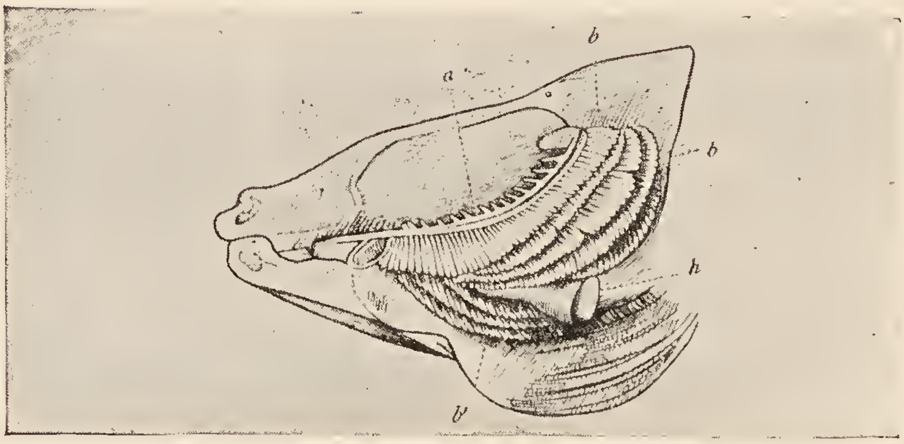


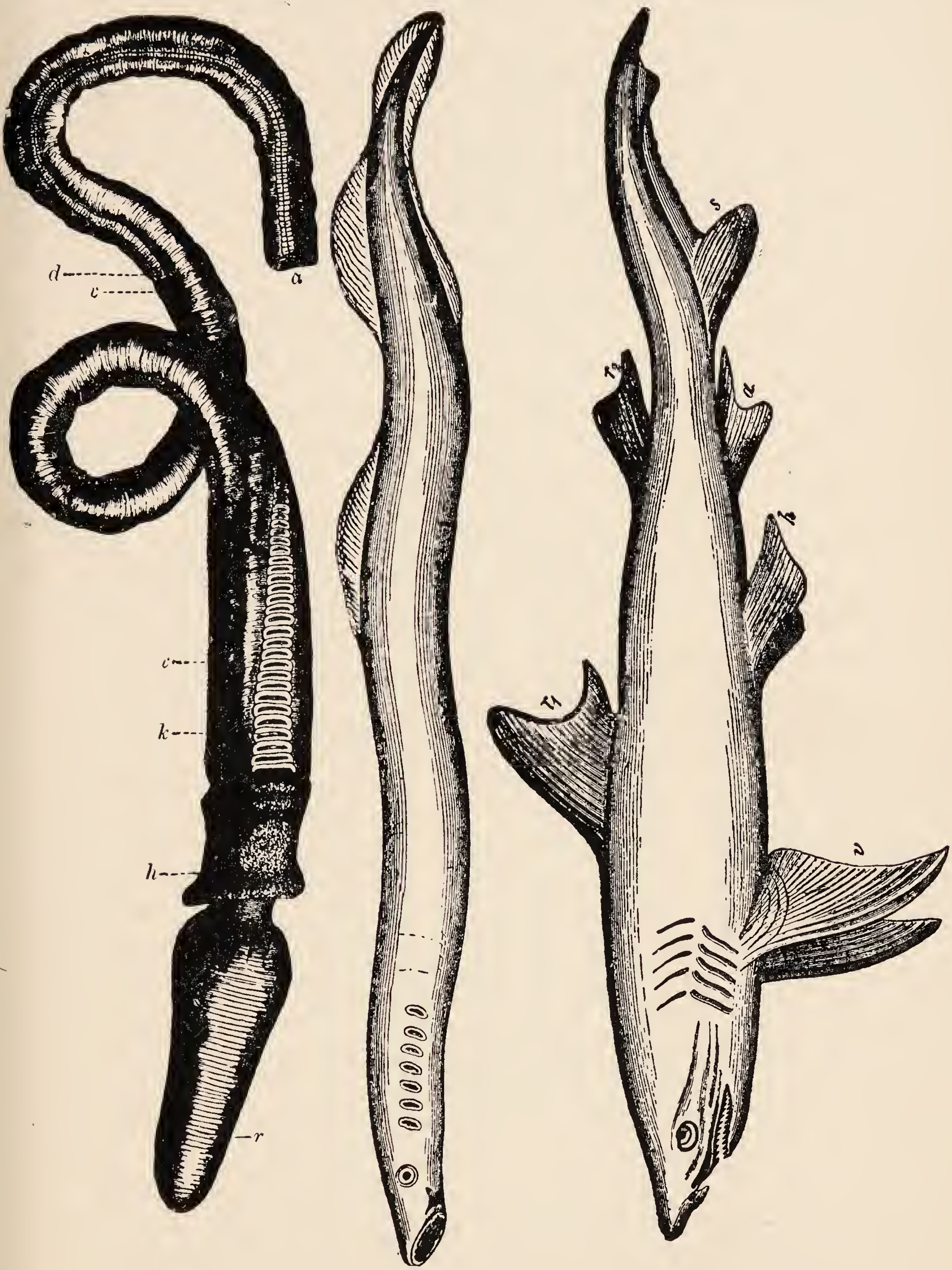
Fig. 82.—The Gills of the Perch.

Every vertebrate possesses, sooner or later, gill-slits, a notochord, and a hollow body. These marks are therefore of the utmost value in helping us to trace the ancestry of animals.

Gills were developed to enable the animal to breathe the oxygen in water. The arrangement is shown in Fig. 84.

We shall see some wonderful object-lessons in Fig. 85 when we grasp its details.

I. is an ideal diagram of primitive gill or aortic arches. H, outline of heart. The arrows show the course of the blood.


d
v
a
c
k
h
r
s
r2
a
b
r1
v

I. II. III.

FIG. 83.—Acorn-Worm, Lamprey, and Shark.

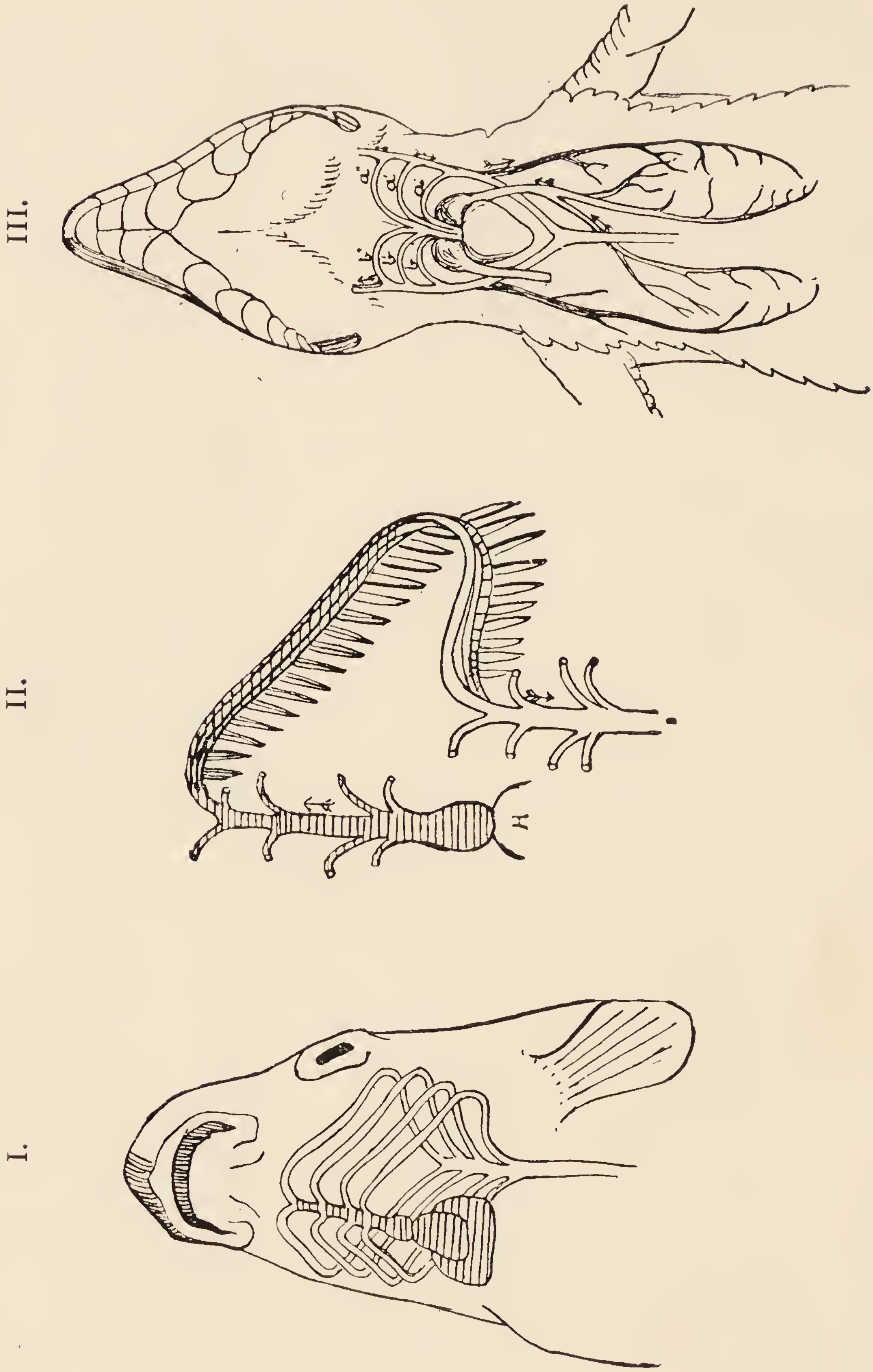


Fig. 84.—Hearts and Gill-arches. I., diagram of heart and gill-arches of a fish; II., one gill-arch with branchial fringe attached; H, heart; III., heart and gill-arches in a lizard. The gill-arches, *a, a', a''*, and *b, b', b''*, are called aortic arches in air-breathing vertebrates.

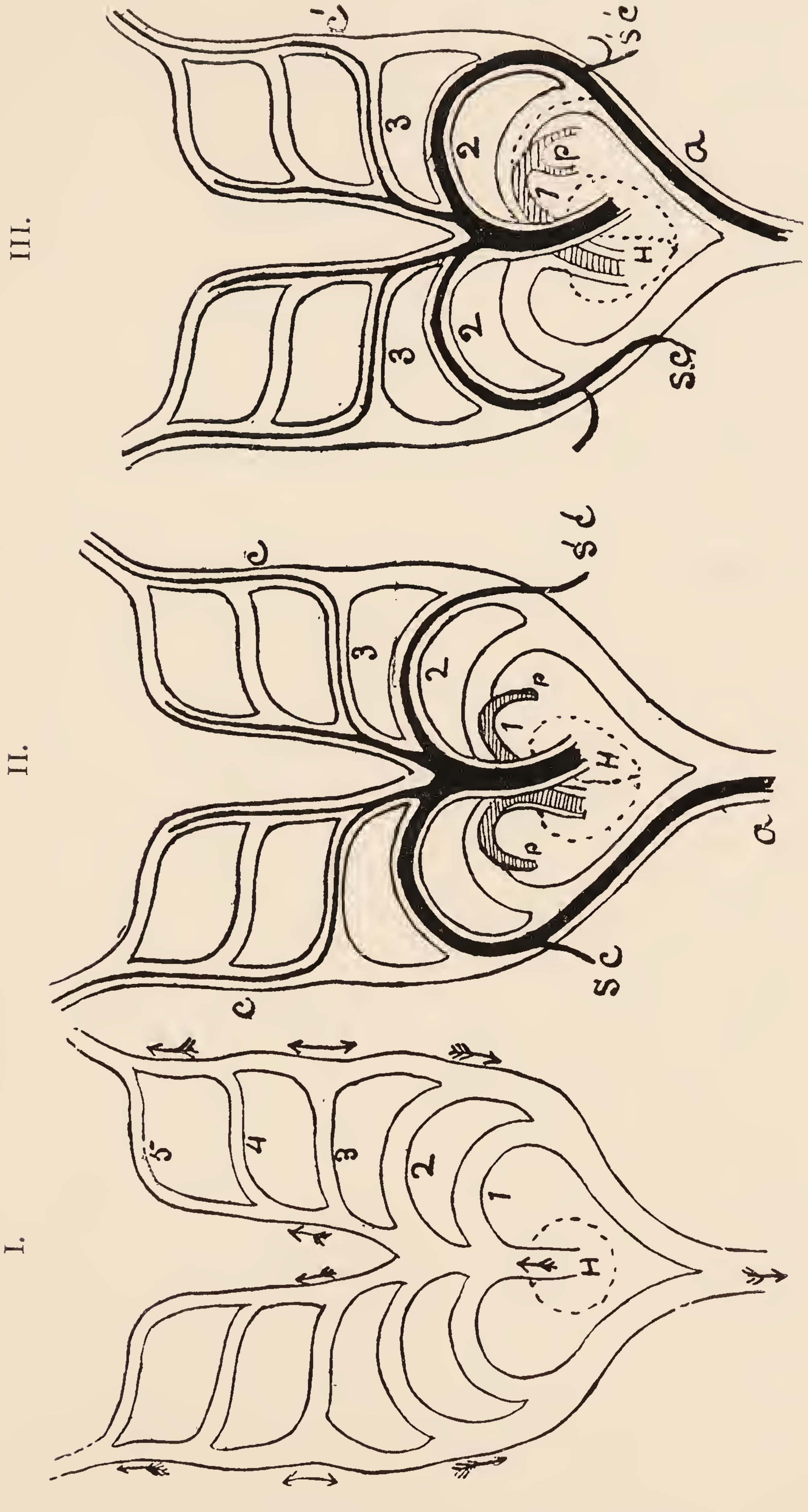

III.
II.
I.
1
2
3
4
5
H
p
a
c
c'
sc
sc'

FIG. 85.—Diagrams of Gill or Aortic Arches.

II. is the same, modified for a bird. At first it has the full set of arches, but many of them disappear. The dark lines show those that remain. *a,* aorta; *p,* pulmonary arches; *sc, s'c',* subclavian; *c, c',* carotids.

III. is the same, as they become modified in the mammal.

We see that both in the bird and the mammal these arches begin on the original full plan required for a fish; but the heart becomes a far more complex organ, and most of the gill-arches have disappeared. It is interesting to note that though mammals and birds have come through ancestors with the same number of gill-arches, yet the main artery which remains in mammals is not on the same side as the main artery which remains in birds.

This, again, presents a question which only evolution can answer—If mammals and birds have not come from a common ancestor, why do they begin exactly alike in this respect, only to *waste* more than half these gill-arches and adopt quite a different permanent arrangement? We begin to see the value of the evidence of those structures which appear for a time in the life of the embryo and then disappear. They are as sign-posts set on the highways of time, and show us the turns which the human race took in its long journey of mysterious beauty from monad to man.

To prove that these things are not the dreams of imaginative men Fig. 86 is given. The foot marked I is the foot of a foal before birth, with its three toes marked II, III, IV. Foot V is the foot of the hipparion (see Figs. 10, 61, 91, Part I.). Now here, in the number of the toes, we see in foot I the story told of the times when the hipparion roamed over the plains of Europe. The show as [illegible] the chicken as in the fish, and as

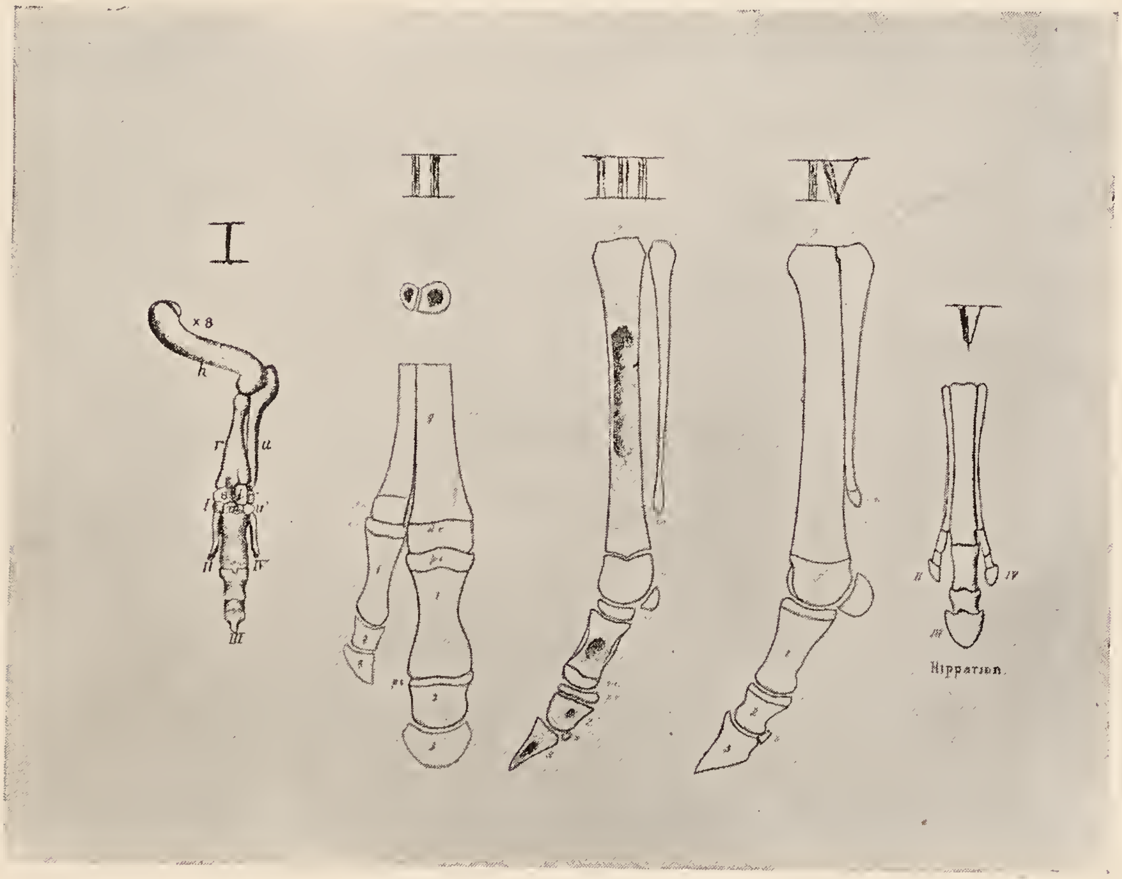


FIG. 86.—Fœtal Feet.

much in man as in either. These marks carry us back to a time when man's ancestors had never dwelt on the land, several million years ago. They are the indisputable records of ancestral origins and limitless antiquity.

RUDIMENTS.

In most animals there are certain parts which are of no use to them. These parts are called

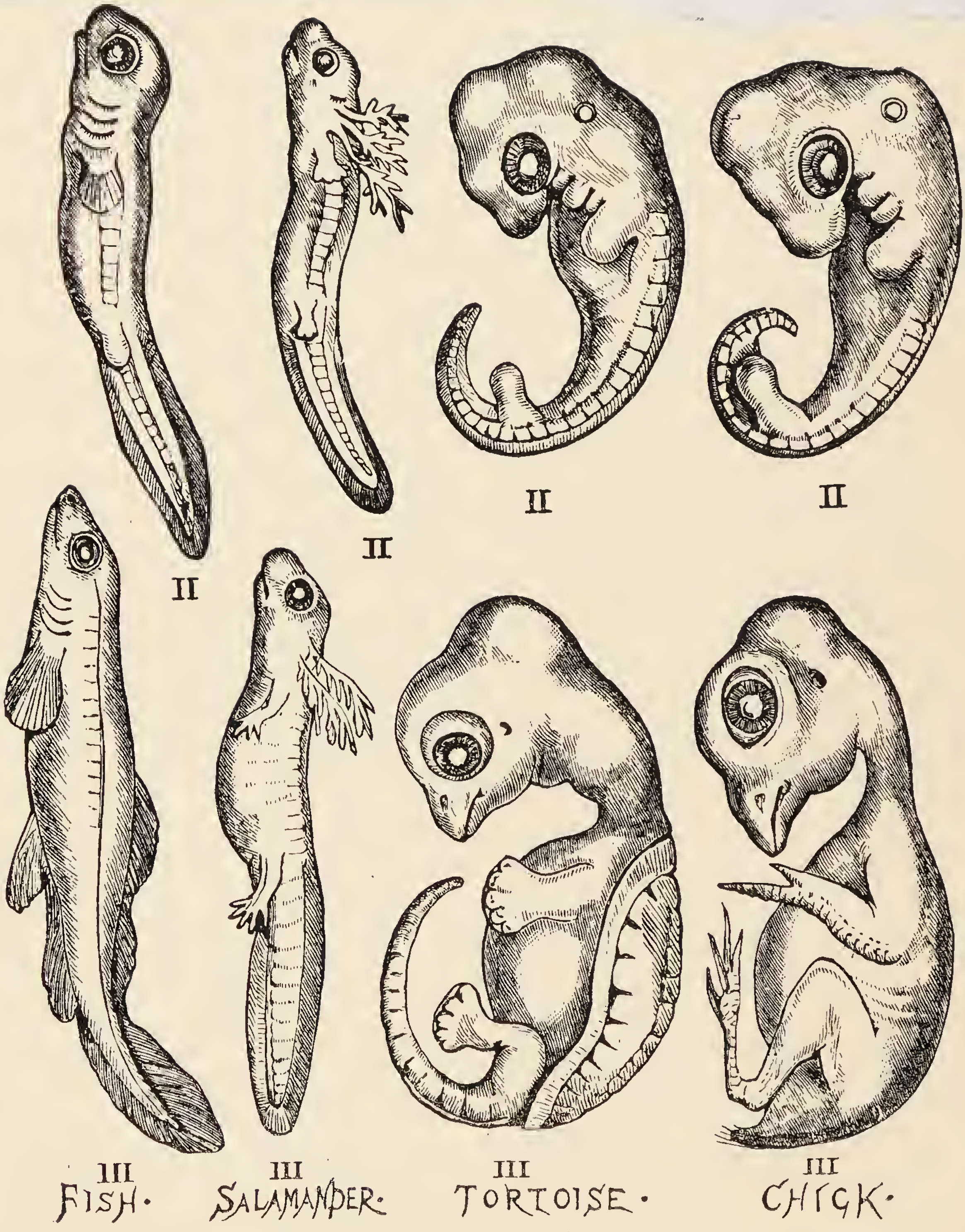

II
II
II
II
III
FISH.
III
SALAMANDER.
III
TORTOISE.
III
CHICK.

FIG. 87.—A Group of Embryos.

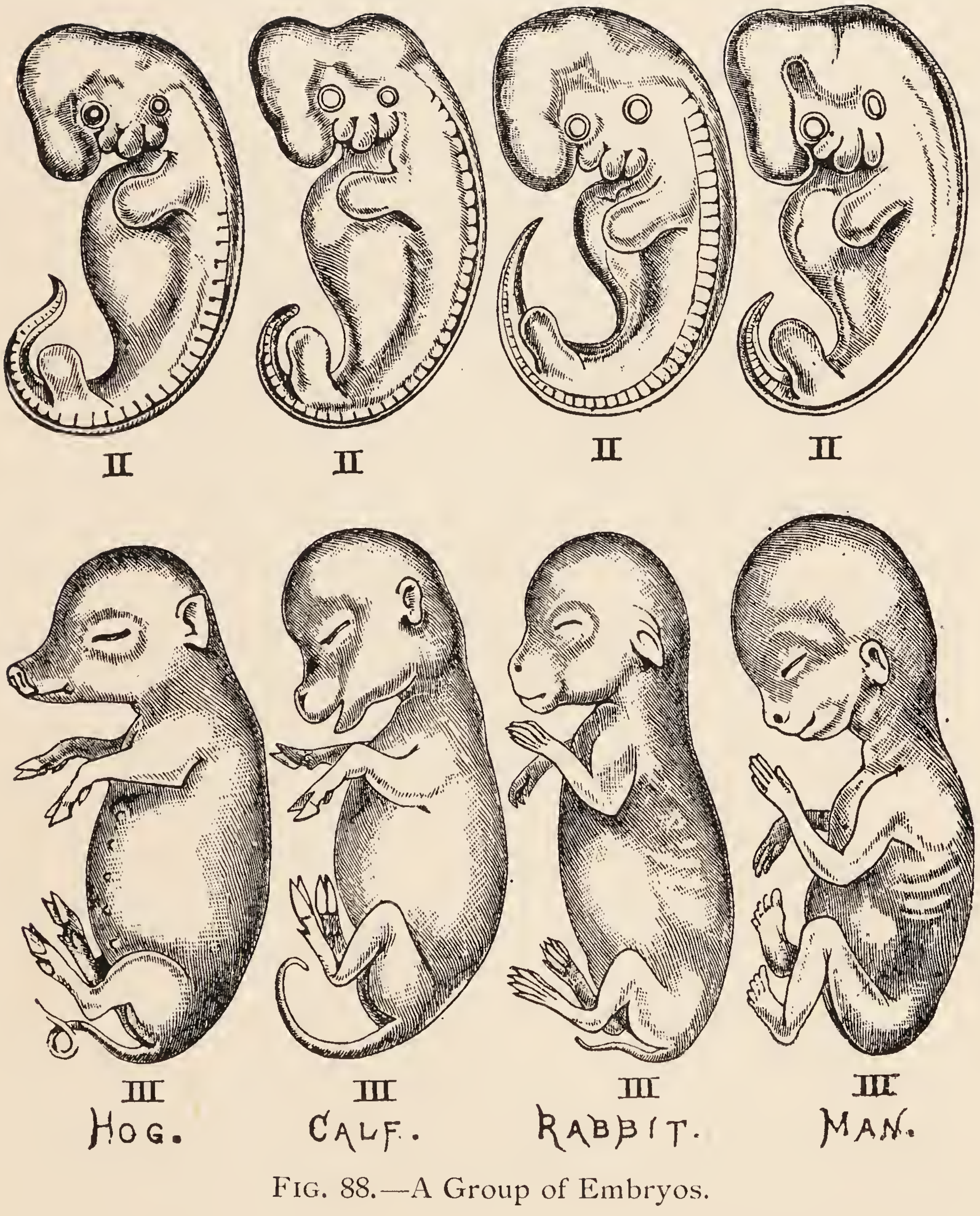

II
II
II
II
III
Hog.
III
Calf.
III
Rabbit.
III
Man.

Fig. 88.—A Group of Embryos.

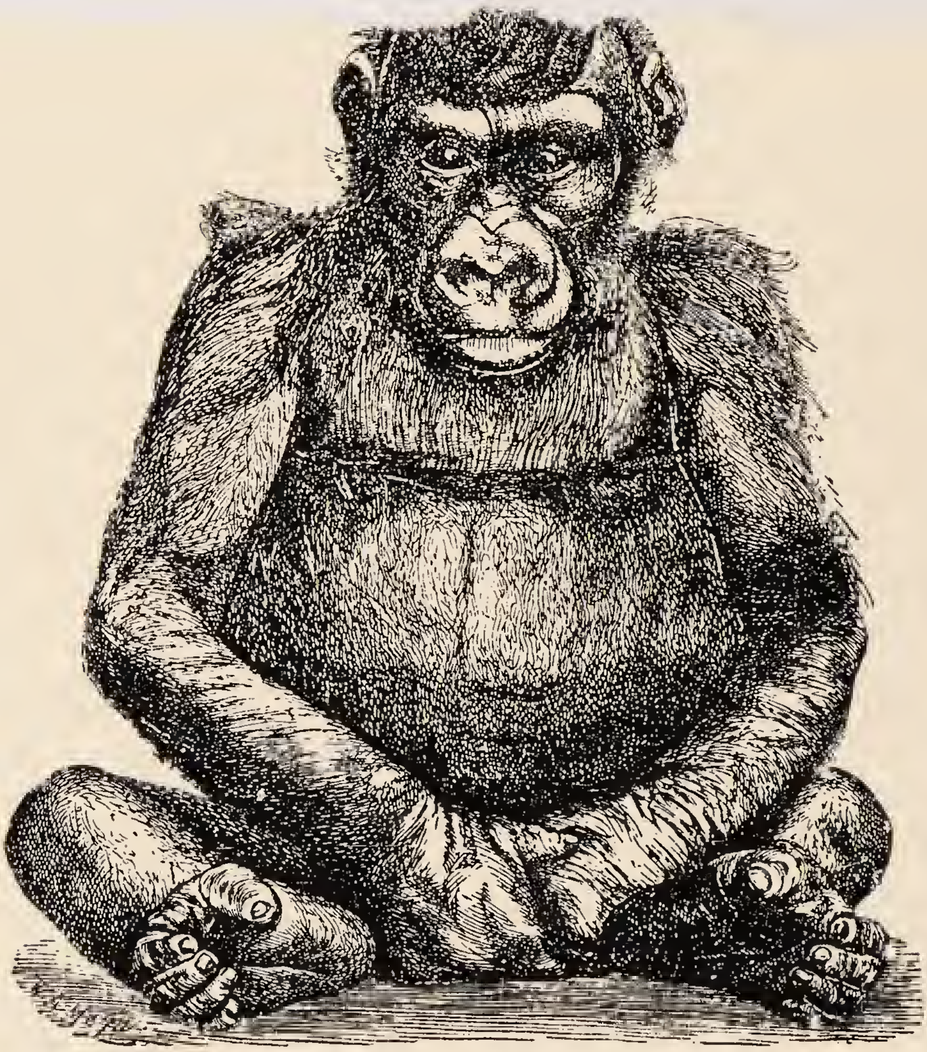


FIG. 89.—A Drawing of a young Ape. (After *Romanes.*)

living animals, about half of them insects," and that it is very wonderful that these animals can be arranged in "at least a plausible genealogical tree," also that structures "fundamentally the same appear with varied form and function." He then says: "Why this adherence to type if animals are independent of one another? How necessary it is, if all are branches of one tree.

"By rudimentary organs, also, the same conclusion is suggested. What mean the unused gill-clefts of reptiles, birds, and mammals, unless the ancestors of these classes were fish-like? What mean the teeth of very young whale-bone whales, of an embryonic parrot and turtle, unless they are vestiges of those which their ancestors possessed? There are similar vestigial structures among most animals. In man alone there are about seventy little things which might be termed rudimentary; his body is a museum of relics. We are familiar with unsounded or rudimentary letters in many words; we do not

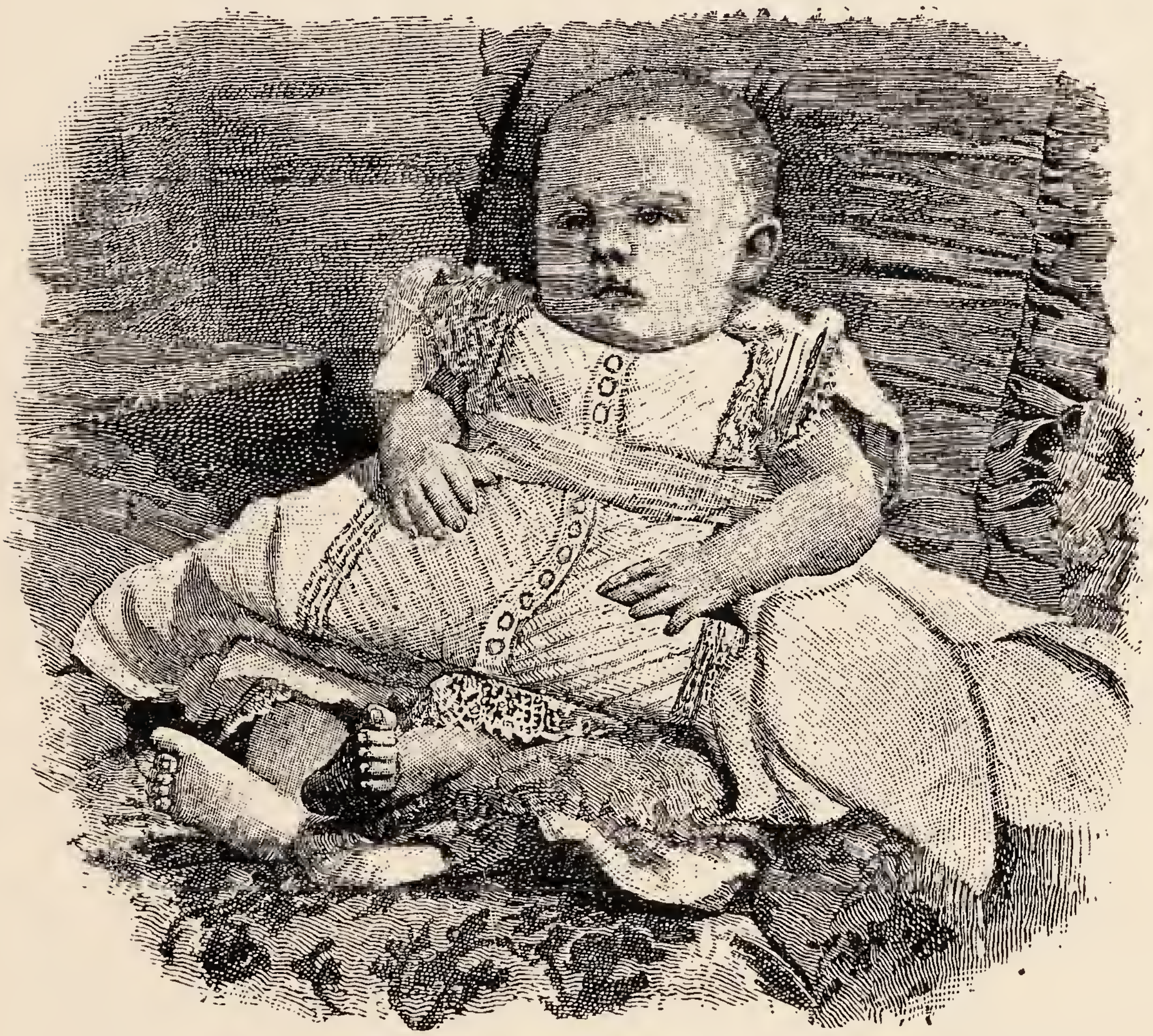


FIG. 90.—Portrait of a young Male Child. (After *Romanes.*)

sound the 'o' in leopard or the 'l' in alms; but from these rudimentary letters we read the history of the words."

Many actions of animals may be said to be vestigial, as well as various parts. This is the explanation offered of the fact that human beings have to *learn* to swim. Their ancestors lived so long in trees that when they are first thrown into the water they clutch at it as if they were clutching at branches.

In this respect interesting observations can be made upon very young children. Infants bend their feet inwards, so that the soles, in a great measure, face one another. This is still more marked in the embryo. (See "Man," bottom line, Fig. 88.) It plainly refers to a state of things in the monkey family, for in all these animals the feet are turned inwards, so as to help them to grasp the branches.

Study the feet in Figs. 89 and 90.

Figs. 89 and 90 illustrate, also, two other vestigial characters, which have been noticed by many writers on this subject. These are the incurved form of the legs and the lateral extension of the great toe, whereby it approaches the thumb-like character of this organ in the apes.

"The grasping power of the whole human hand is so surprisingly great at birth, and during the first few weeks of infancy, as to be far in excess of present requirements on the part of a young child." This seems to refer to our ape-like ancestry, "the young of the anthropoid apes being endowed with similar powers of grasping, in order to hold on to the hair of the mother when she is using her arms for the purposes of locomotion." Professor Romanes adds: "This inference appears to me justifiable, inasmuch as no other explanation can be given of the comparatively inordinate muscular force of an infant's grip" (Vol. I., p. 80).

But, leaving functions, we may look at a few structures; and here, at any rate, there will be no room for doubt.

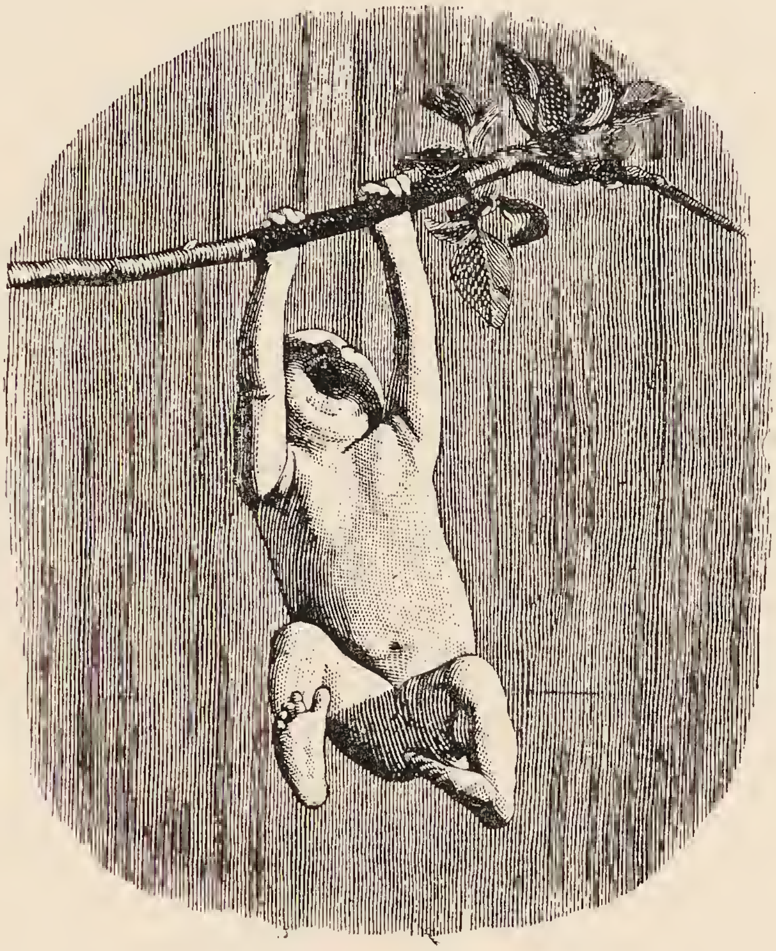


FIG. 91.—An infant, three weeks old, supporting its own weight for over two minutes. The attitude of the lower limbs, feet, and toes is strikingly ape-like. (From an instantaneous photograph by *Dr. L. Robinson.*)

For example, throughout the vertebrate series, from fish to mammals, there occurs in the inner corner of the eye a semi-transparent eyelid, which is called the nictitating membrane (Fig. 92). The object is to sweep rapidly over the surface of the eye to keep it clean. It is quite easy to see fowls using this membrane; but no man can use it. Millions of human beings do not know that they

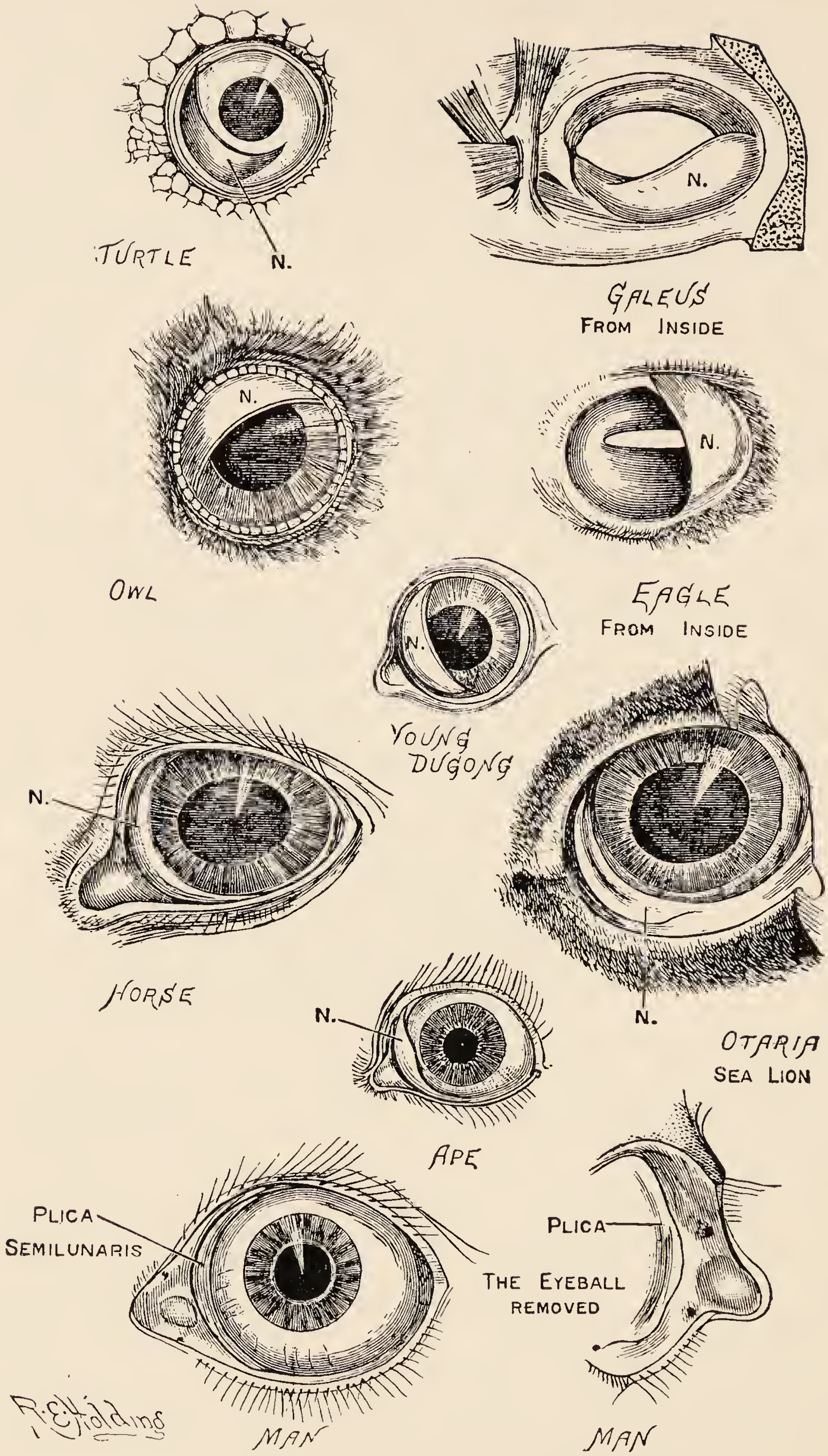

TURTLE
N.
GALEUS
FROM INSIDE
N.
N.
OWL
N.
EAGLE
FROM INSIDE
N.
YOUNG
DUGONG
N.
HORSE
N.
N.
OTARIA
SEA LION
APE
PLICA
SEMILUNARIS
PLICA
THE EYEBALL
REMOVED
R. E. Fielding
MAN
MAN

FIG. 92.—Illustrations of the nictitating membrane in the various animals named. The letter N indicates the membrane in each case. In man it is called the plica semilunaris, but it is the same thing.

have it; yet we all possess it. Why? There seems no other reason except that the horse, the eagle, and man have come from some common ancestors.

In Fig. 93 we see the organ which is the source of so much trouble, when inflamed. The disease appendicitis is well-known now. In this figure the appendix is the smallest of the structures shown —the only one that is not cut. This structure is large and useful among many herb-feeding animals; but in man it is too small to serve any such purpose, and is a source of great danger to his life. In the orang it is much bigger than in man, and also relatively in the human fœtus. Why should man have such an organ?

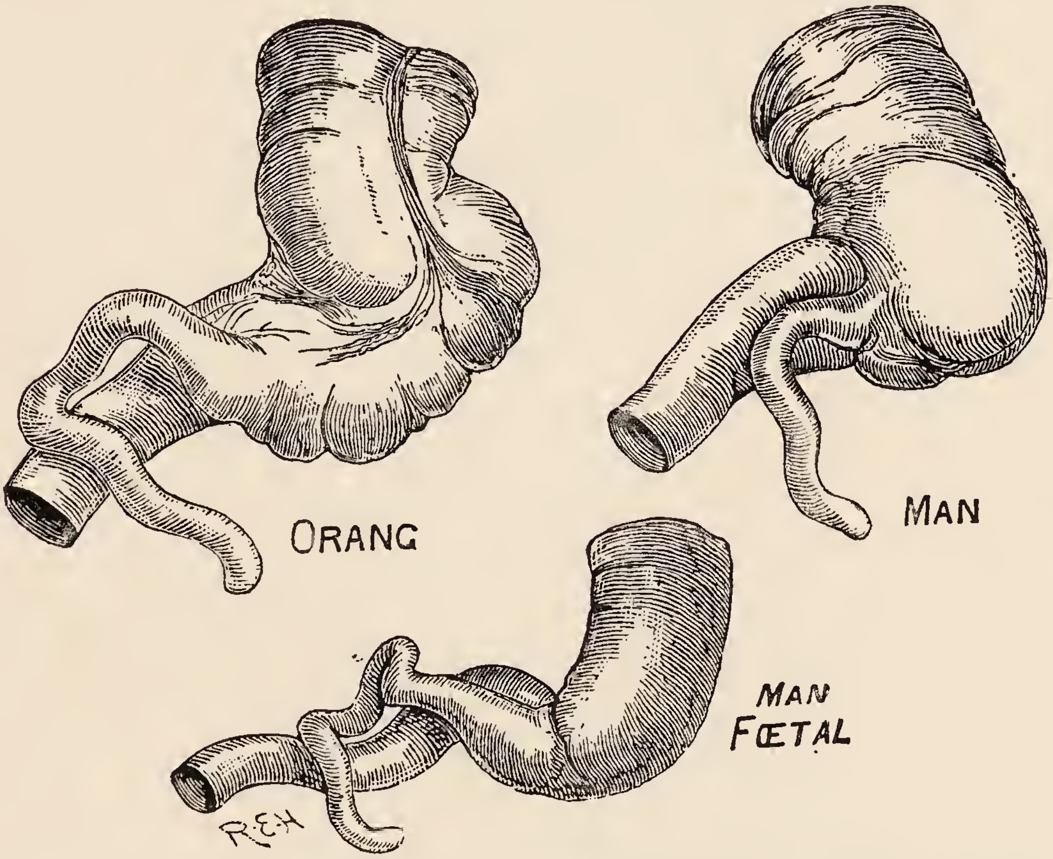


FIG. 93.—The Appendix Vermiformis (the worm-like appendix).

If you tell the ordinary intelligent man in the drawing-room or a shop that his ancestors were able to move their ears up and down, as horses and dogs do now, he would either feel very hurt or mistake you for the only living comedian. But in Fig. 94 you see the muscles, which every man yet has, and most of which he cannot use. Yet these very muscles are the same as those which other animals use for the purpose of moving the ears up and down.

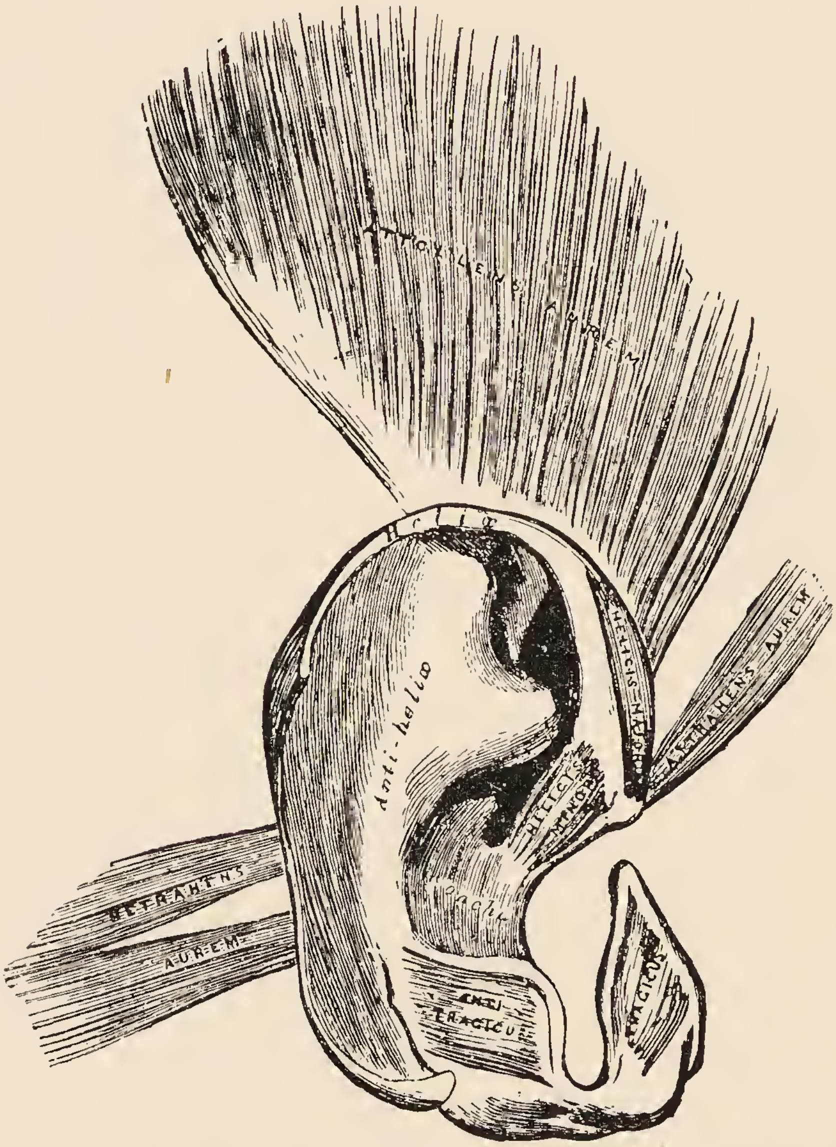

ATTOLLENS AUREM
Helix
Anti-helix
HELICIS MAJOR
ATTRAHENS AUREM
HELICIS MINOR
RETRAHENS
AUREM
Concha
ANTI TRAGICUS
TRAGICUS

FIG. 94.—The Rudimentary, or vestigial and useless, Muscles of the human ear.

Perhaps those people whose pride will not allow them to think of themselves would be able to see this difficulty more clearly in "the lower animals." Now, in Figs. 95 and 96 we have the same lesson from rudiments given in a most striking way.

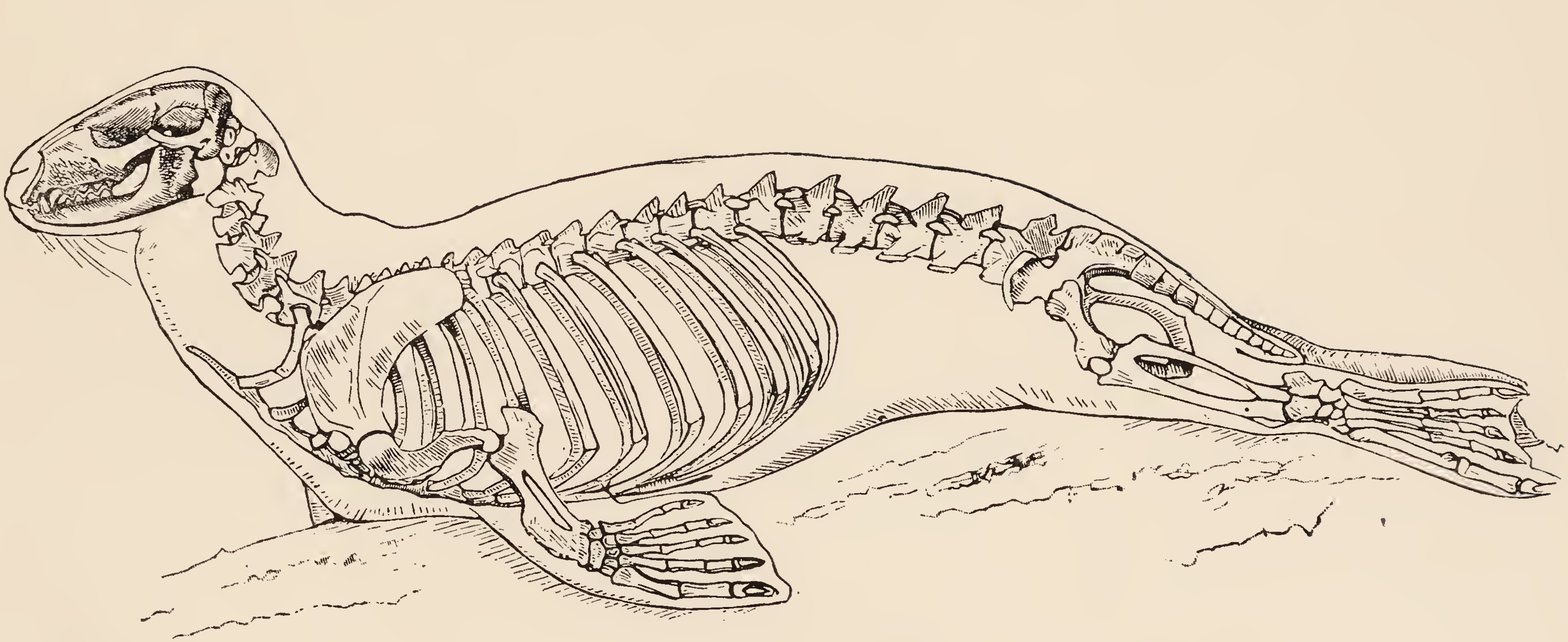


FIG. 95.—Skeleton of a Seal.

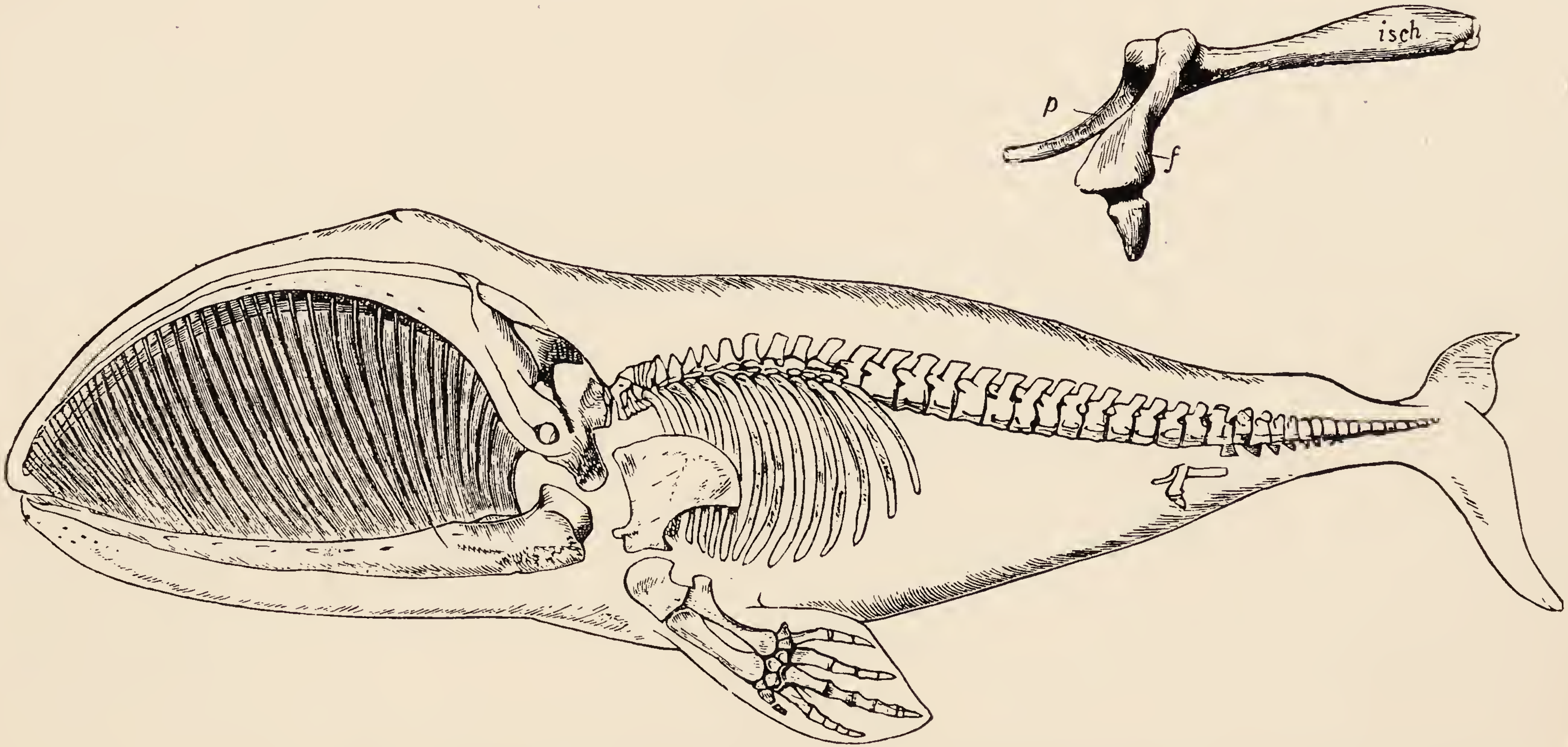


FIG. 96.—Skeleton of Greenland Whale, $\frac{1}{100}$th natural size. The rudimentary bones of the pelvis are shown on a larger scale in the upper drawing.

The seal and the whale, which many think are fish, must have come from four-legged ancestors. In the seal (Fig. 95) we see all the bones of the hind legs shortened up and directed backwards, till they seem to form a tail. Most people think it is a tail.

"In the whale the changes have gone still further, so that the hind legs have ceased to exist externally, and are only represented internally—and even this only in some species—by remnants so rudimentary that it is difficult to make out with certainty the homologies of the bones."

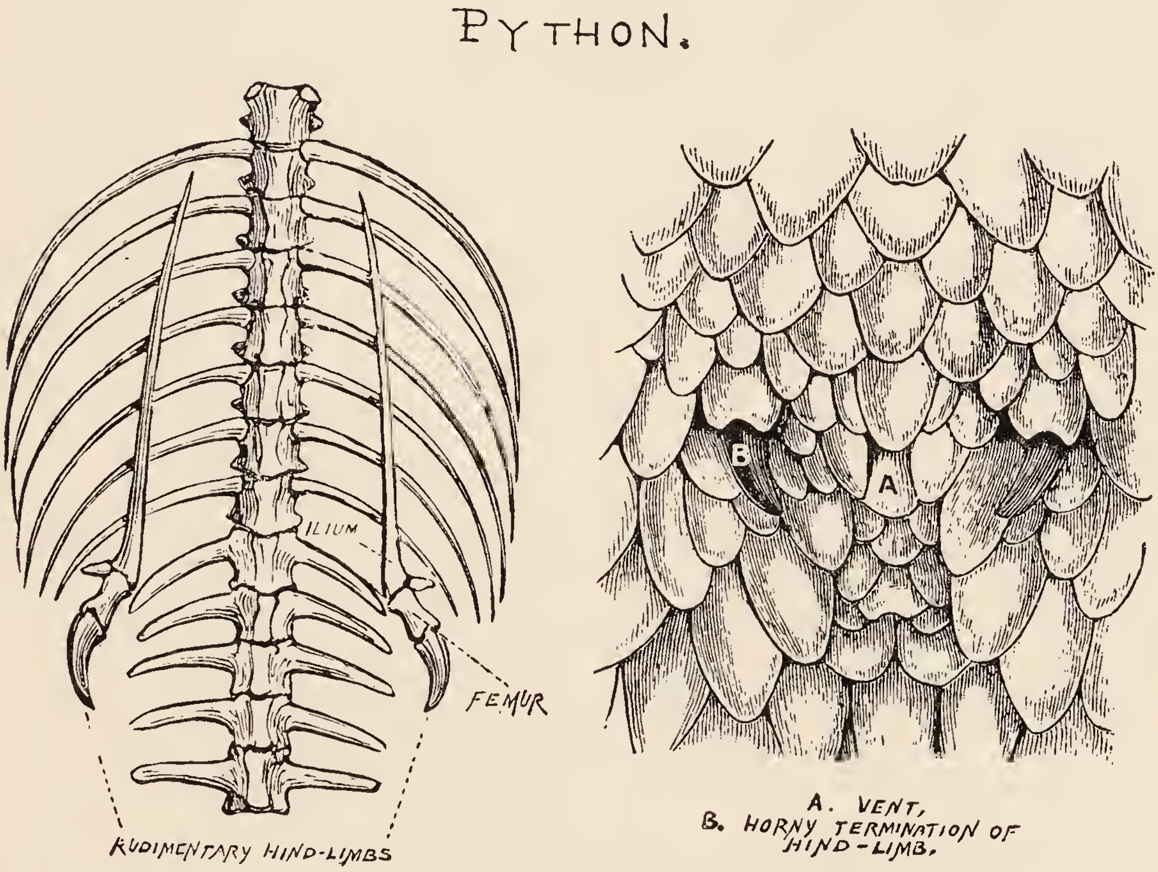


FIG. 97.—The Python.

Now, surely no one can deny this fact or refuse to learn this lesson. Seals and whales come from land animals. No one would dare to suggest that the beautiful hands of the seal and whale, which, as *hands,* are absolutely useless, were created thus merely to be hidden in a fin-shaped sack so as to render them useless.

Still more striking is the case of the python (Fig. 97). In fact, it is almost grotesque. In the

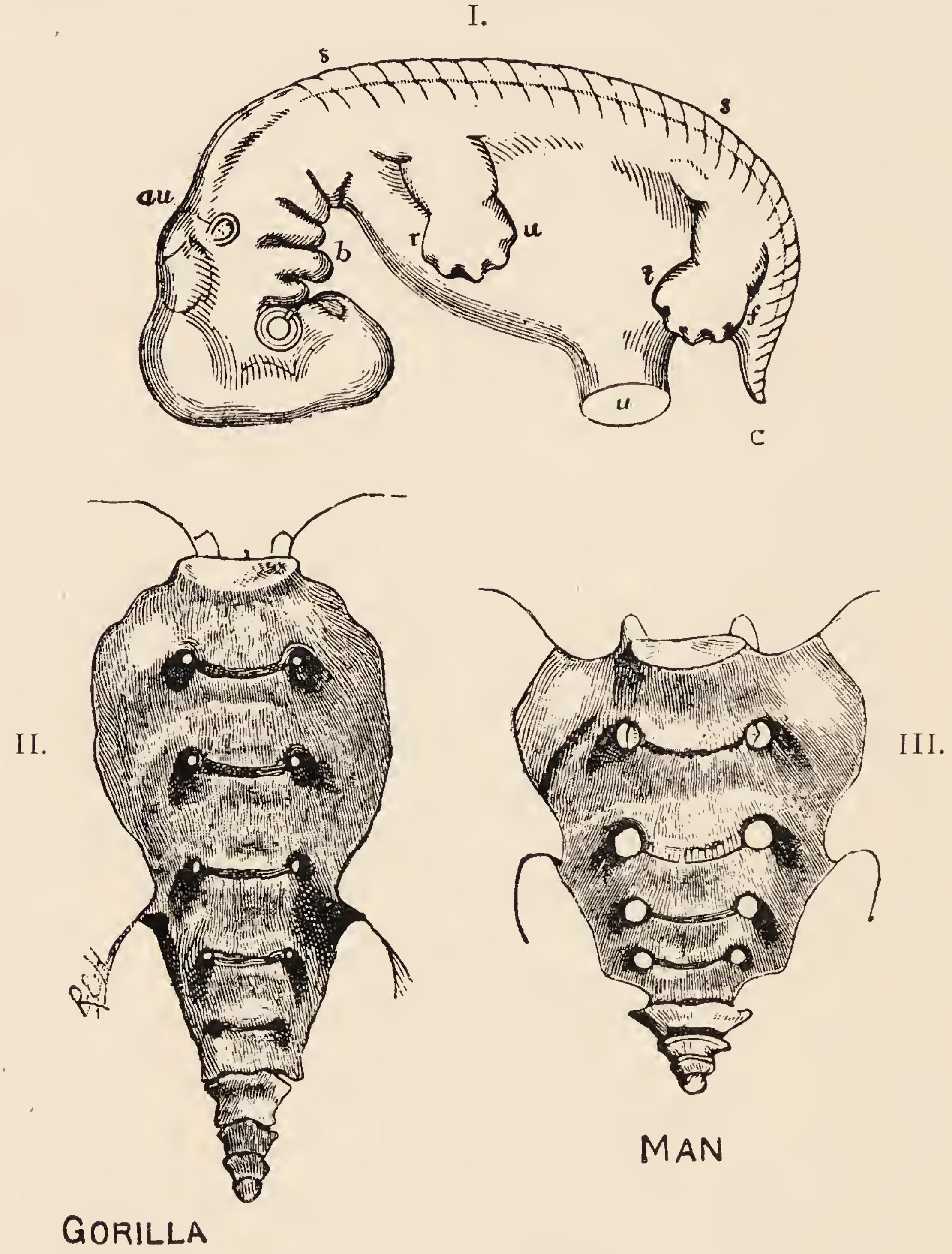


Fig. 98.—On Tails. I. Outline of the human embryo, about seven weeks old, showing the relation of limbs and tail to the trunk. *r,* the radial, *u,* the ulnar border of the hand and fore-arm; *t,* the tibial, and *f,* the fibular border of the foot and the lower leg; *au,* ear; *s,* spinal cord; *u,* umbilical cord; *b,* branchial gill-slits; *c,* tail. II. and III., the sacrum of Gorilla compared with that of Man, showing the rudimentary tail-bones of each.

figure on the right two little black claws are visible, one of them marked B. These are useless, and it is not until we see the skeleton on the left that we are able to realise they are the end of all that is left of the legs!

It would not be well to leave this branch of our subject, where these extreme examples border upon burlesque, without a word about the early wit that was levelled against Darwin's remarkable discovery when first it was given to the world. I refer, of course, to the popular difficulty that man had no tail, and therefore could not be related to a barrel-organ monkey! To many this is still the complete theory of evolution, and one is inclined to say that they have not got hold of the tail-end of it.

We have just seen how organs can be reduced to small rudiments in various animals. Now, Fig. 98 shows three remarkable objects bearing on this witty tail question.

It should be noted that in No. I. of this figure we have a little animal, four-legged, with a tail *longer* than its hind leg.

In II. and III. we find the same structure in man as in the gorilla. Of course, none of the anthropoid apes have an *external* tail; but they possess the rudimentary vestiges of a tail "in a few caudal vertebræ below the integuments." So also does man.

Not only so; but man still has the muscles for "wagging" a tail, as we have seen that he has the muscles for moving his ears.

Could anything be more clearly shown than this, that man has come from a four-footed, long-tailed ancestor? This can be seen in Fig. 99.

This is a remarkably small object, when you consider the enlargement is three diameters—*i.e.*, about nine times.

Still you can see the little round bulges which are going to develop into an arm and a leg; but the tail is two or three times longer than the leg.

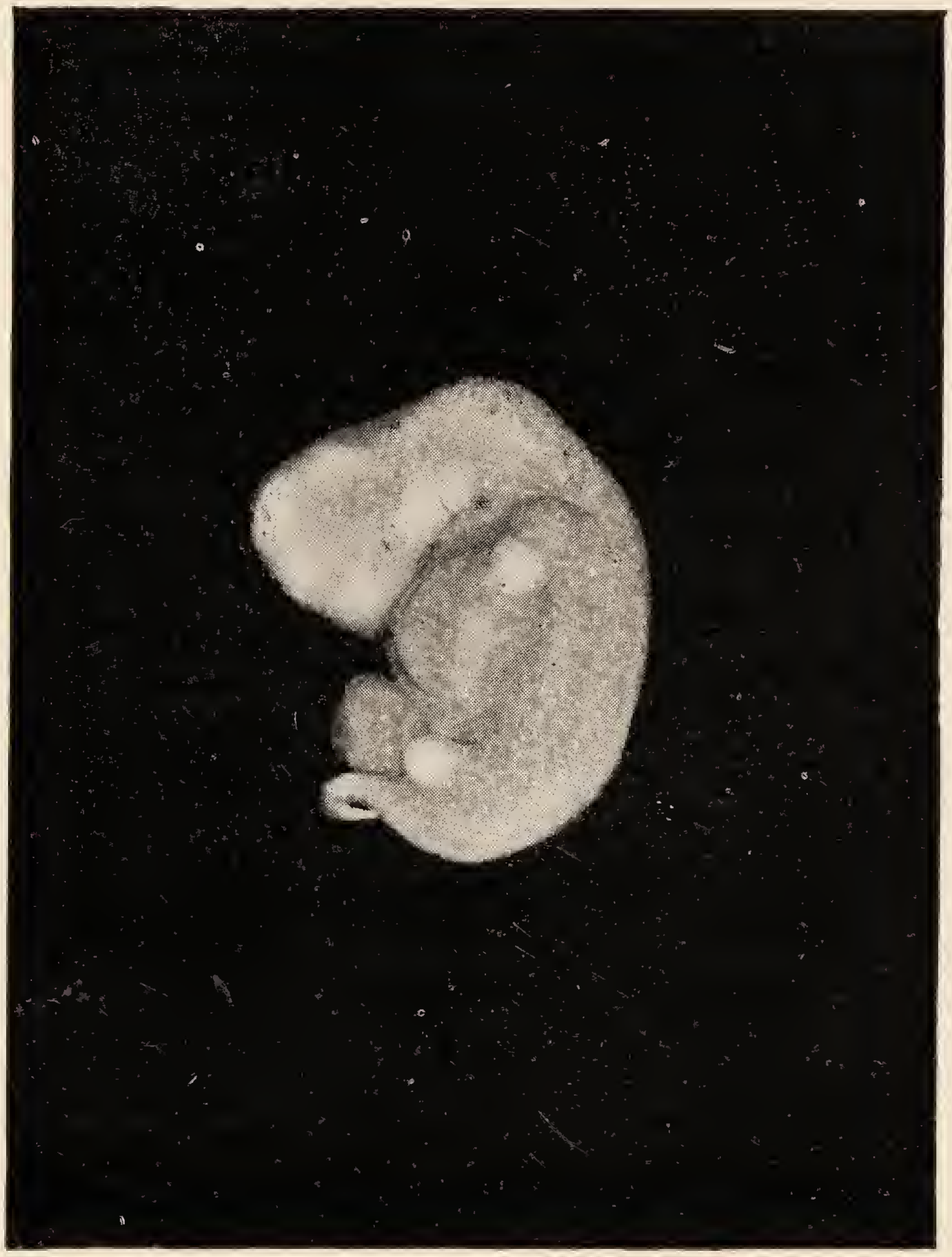


FIG. 99.—A Human Embryo from the thirty-second to the thirty-fifth day—*i.e.*, about the fifth week. Enlarged about three diameters. (From *Professor Arthur Thomson.*)

This little curly tail is a photograph from nature, and not a piece of imagination. It not only answers the whole of the tail difficulty, but throws a flood of light on the early condition of man's ancestors.

For the lesson from this picture is found in the *size* of the picture itself. This tail does not occur late in the life of the embryo, but early ; for it is a feature of *early* ancestors. So the embryo is not large, but small, when it has a tail, because the tailed ancestors were small creatures—probably between the size of a mouse and a rat.

CHAPTER IV.

PEDIGREE OF MAN

[In reading this chapter it should be noted that the text runs on continuously with the groups marked. The pictures also follow in order, and beneath each the group to which it belongs is indicated.]

FEW things are more striking or more interesting than to turn from a book of zoology written thirty or forty years ago to one of to-day. The modern book shows such a principle of unity in dealing with all animals, and above all such marvellous knowledge of the origin of man, that it offers a new world to the reader. In all cases now man is grouped under Primates, together with the monkeys and apes, unless it be in some American book on Natural History for Sunday schools.

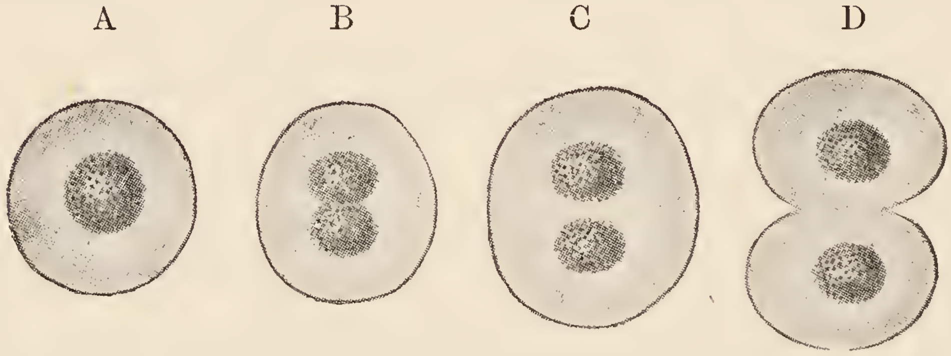


FIG. 100, Group I.—Chroococcus Minor (vegetable), magnified 1,500 times. The unnucleated globule of plasm (bluish-green in colour) increases by simple cleavage, as seen in A to D.

To seek the origin of man we must look for the origin of mammals, then the origin of vertebrates, for it can be proved to a demonstration that man is not a creature apart from all other animals. He is one of the larger family, and he must have family connections.

This lends a deep interest to the stages of growth

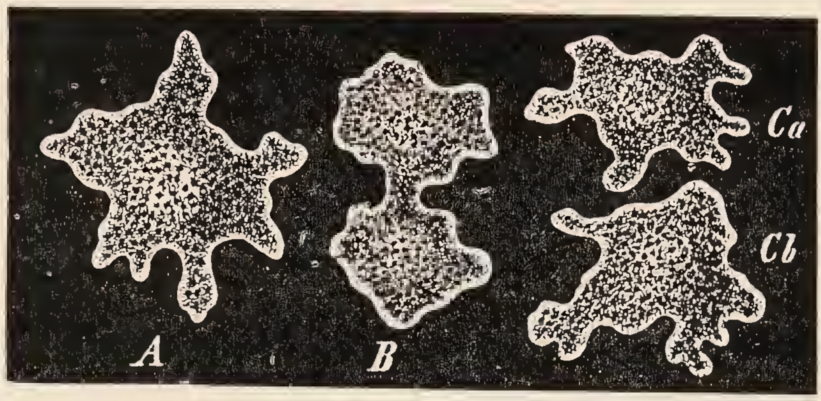


FIG. 101, Group I.—The Protamœba (animal) in the act of reproduction. A, the whole moner moving like an ordinary amœba by thrusting out changeable processes. B, it divides into two halves by a constriction in the middle. C, the two halves separate, and each becomes an independent individual. (Highly magnified.)

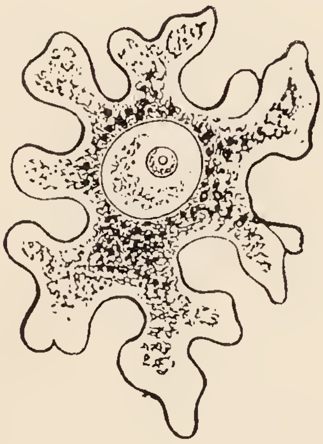


FIG. 102.

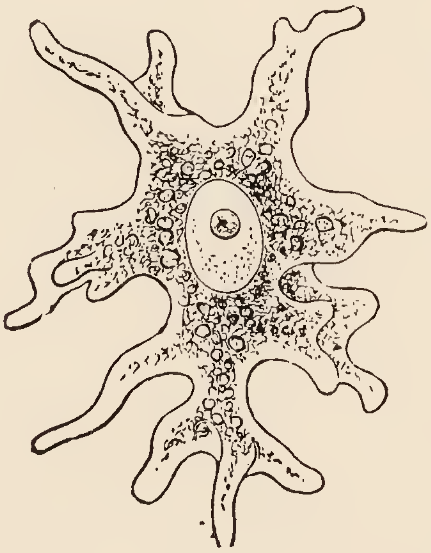


FIG. 103.

FIG. 102, Group II.—A Creeping Amœba (highly magnified). The whole organism is simply a naked cell, and moves about by means of the variable processes that it thrusts out and withdraws into its protoplasmic body. There is a clear, round nucleus in the middle of it.

FIG. 103, Group II.—The Ovum of a Calcareous Sponge (calcolynthus). The ovum creeps about in the body of the sponge, by the same means as the amœba. This helps us to see how the ovum of the higher animals may have come from an ancient ancestral form, like the common amœba.

in the life-history of animals. Some of these stages should be carefully examined. It is not easy to say which are the most important.

The origin of living things is one of the great stages in the evolution of our little cooling planet, and we can no longer doubt that, just as the chemical elements arose, so, by a more complex chemical process, arose those minute living things which may be vegetable or animal or something between the two.

The next great stage was the development of this formless protoplasm into a cell with a nucleus, capable of discharging all the functions of living things, and multiplying or breeding by simple division of the cell into two.

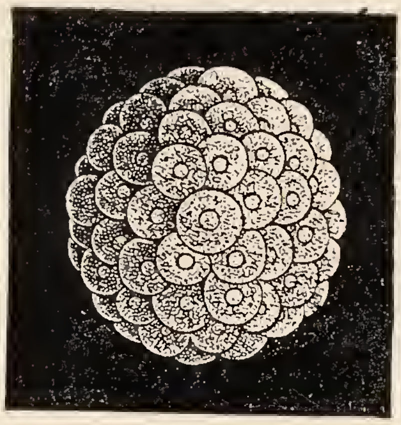


FIG. 104, Group III.—A common example of a Moræad; the morula, or mulberry-shaped embryo. It is really a colony of protozoa, and there are many plants and animals in this form which never advance any further.

This simple law of the growth and multiplication of cells by division has been imposed upon every living thing.

Before cells began to join together in colonies, a singular process took place in cell life. We know that cells multiply by dividing (cleavage) or by budding (gemmation). The earliest animals, consisting only of one cell, reproduced themselves in this way ; but it is observed in these low forms that one cell will absorb another, and then become far more active and divide very rapidly for a long period. The cell absorbed is a form of nutrition, and furnishes a *chemical* irritant or stimulus. This

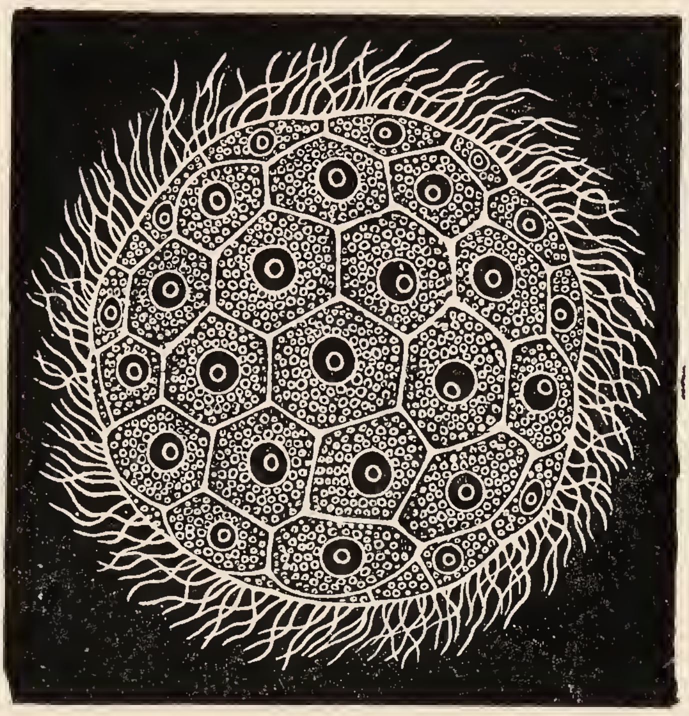


FIG. 105, Group IV.—The Norwegian Magosphæra Planula, swimming about by means of the lashes or cilia at its surface.

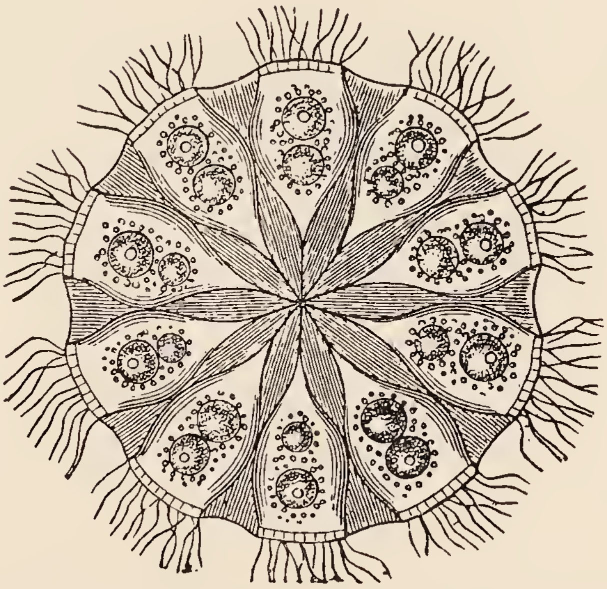


FIG. 106, Group IV.—Section of Fig. 105, showing how the pear-shaped cells in the centre of the gelatinous ball are connected by a fibrous process. Each cell has a contractile vesicle as well as a nucleus.

is the origin and function of sex. At first the two were almost identical, but soon they differentiated; the female cell (ovum or germ) became larger, the male cell (sperm) was smaller. At first both kinds of cells were produced in the same body—many animals still produce both (they are called hermaphrodite or diœcious)—but a further division of labour soon effected the change, now common in all the higher animals, which we recognise under the terms "male" and "female."

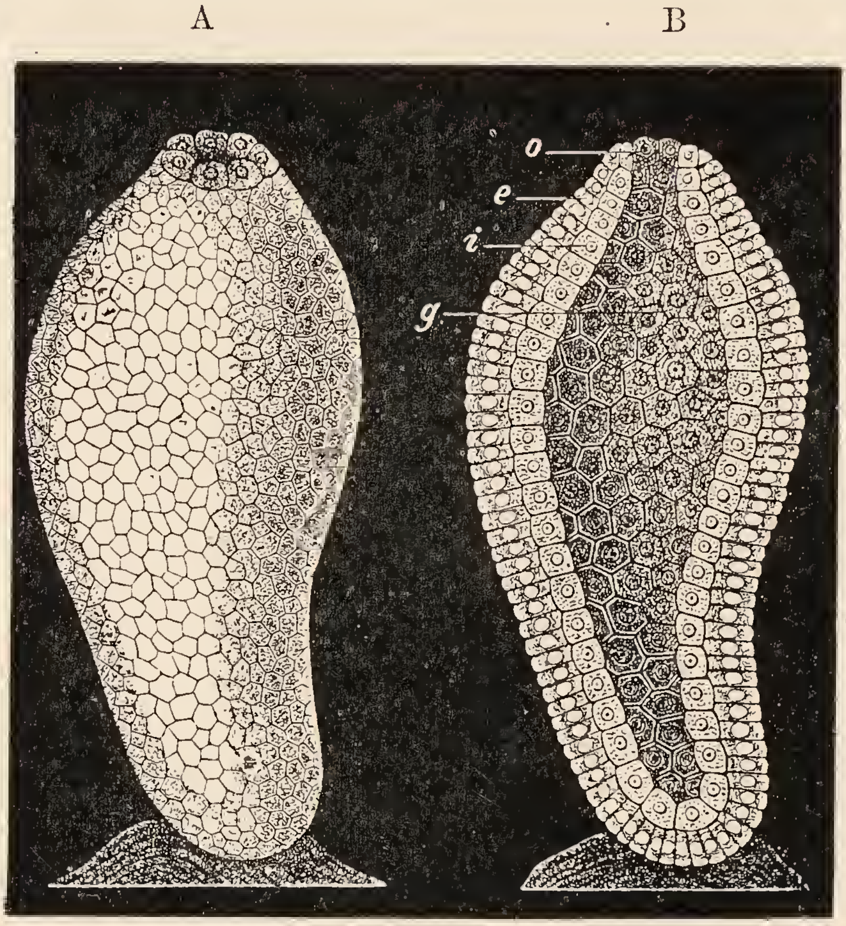


FIG. 107, Group V.—A Gastrula Form, the ascula of gastrophysema, attached to the floor of the sea. A, the external view; B, a longitudinal section; *g,* primitive gut; *o,* primitive mouth; *i,* visceral layer; *e,* cutaneous layer. (For other gastræads see Fig. 99, Part I.)

We thus see that, just as the amœba knew the difference between food and a stone by chemical irritation, so also reproduction can be classed as a chemical function. As these two forms of feeling or irritation may be regarded as primary and in a sense the parent-forms of all emotion, we are compelled to class emotions as a branch of chemistry.

Another great stage in growth occurred when the cells, after dividing, did not separate, but clung together in a somewhat loose fashion to form colonies. This was the grand step to the formation of a body and the discovery of co-operation. All the intelligence and beauty and triumph of the human race owes its origin to this step.

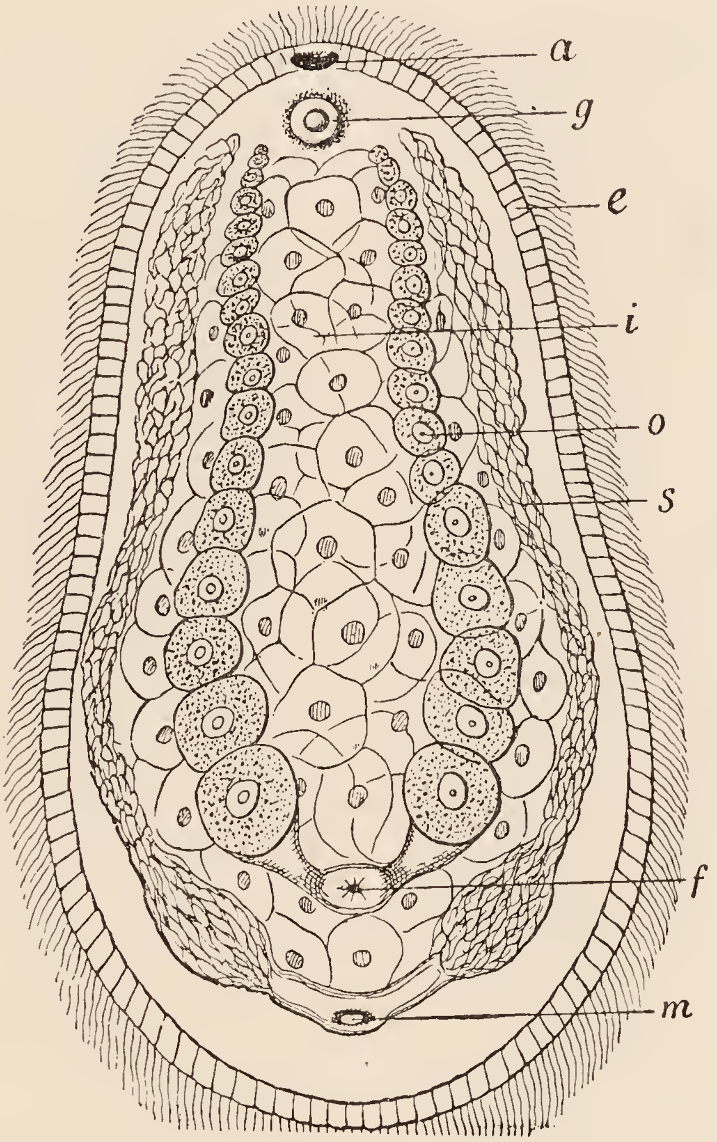


FIG. 108, Group VI.—One of the Platodaria, Aphanostomum Langii. This new species was found at Ajaccio in Corsica, 1899. *a,* mouth; *g,* auditory vesicle; *e,* ectoderm; *i,* entoderm; *o,* ovaries; *s,* spermaries; *f,* female aperture; *m,* male aperture.

Countless multitudes of marvellous forms resulted from the law of the combination of cells. The most interesting to us are certain forms, more or less wormlike, which learnt to grow so as to acquire a hollow body. This may be taken as the fourth step

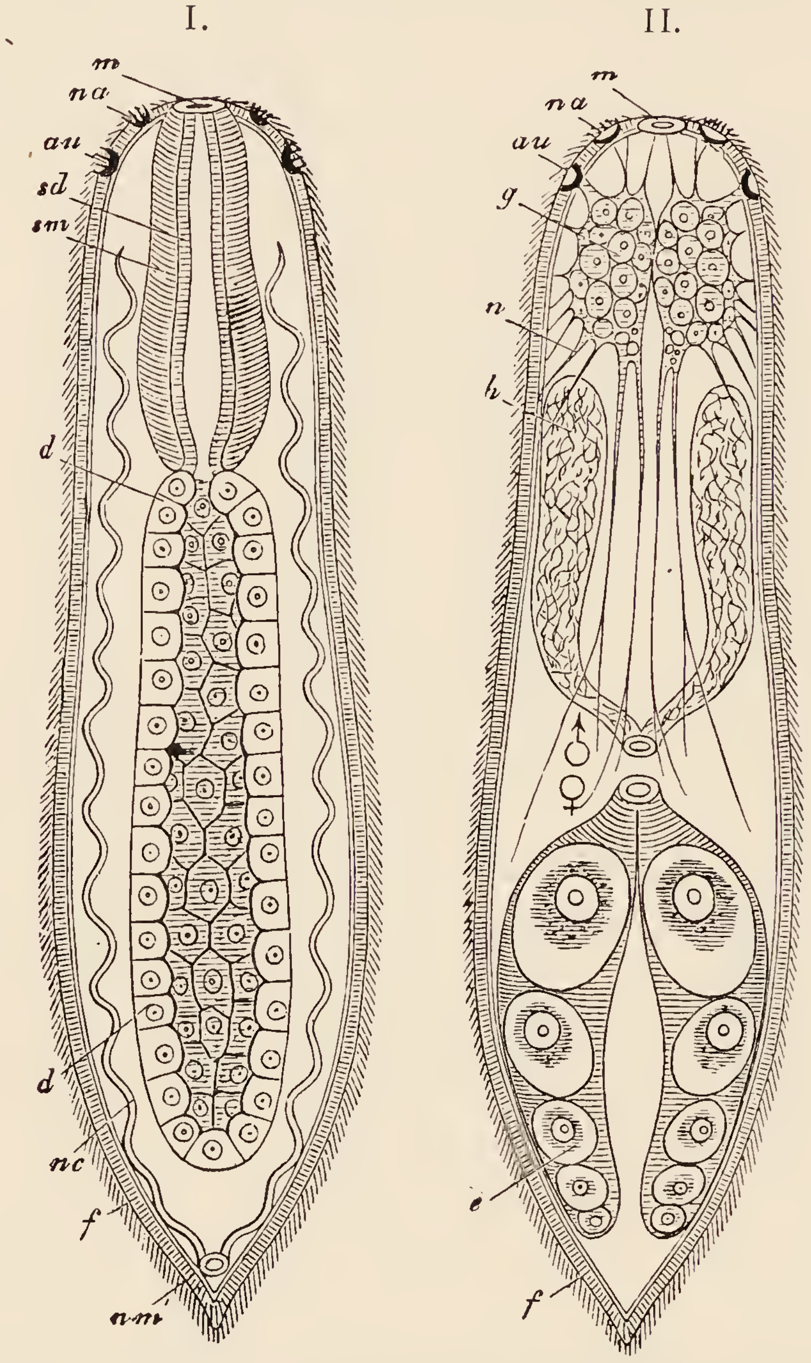


FIG. 109, Group VI.—I., one of the Turbellaria, a simple coiled-worm (rhabdocœlum). *m,* mouth; *sd,* gullet epithelium; *sm,* gullet muscles; *d,* gastric duct; *nc,* renal canals; *nm,* renal aperture; *au,* eye; *na,* olfactory pit. II., The same, showing the other organs. *g,* brain; *au,* eye; *na,* olfactory pit; *n,* nerves; *h,* testicles; ♂, male aperture; ♀, female aperture; *e,* ovary; *f,* ciliated epiderm.

in that wonderful march through the ages, when matter was in quest of organisation, and therefore in quest of a higher life.

The acquirement of special organs to enable the

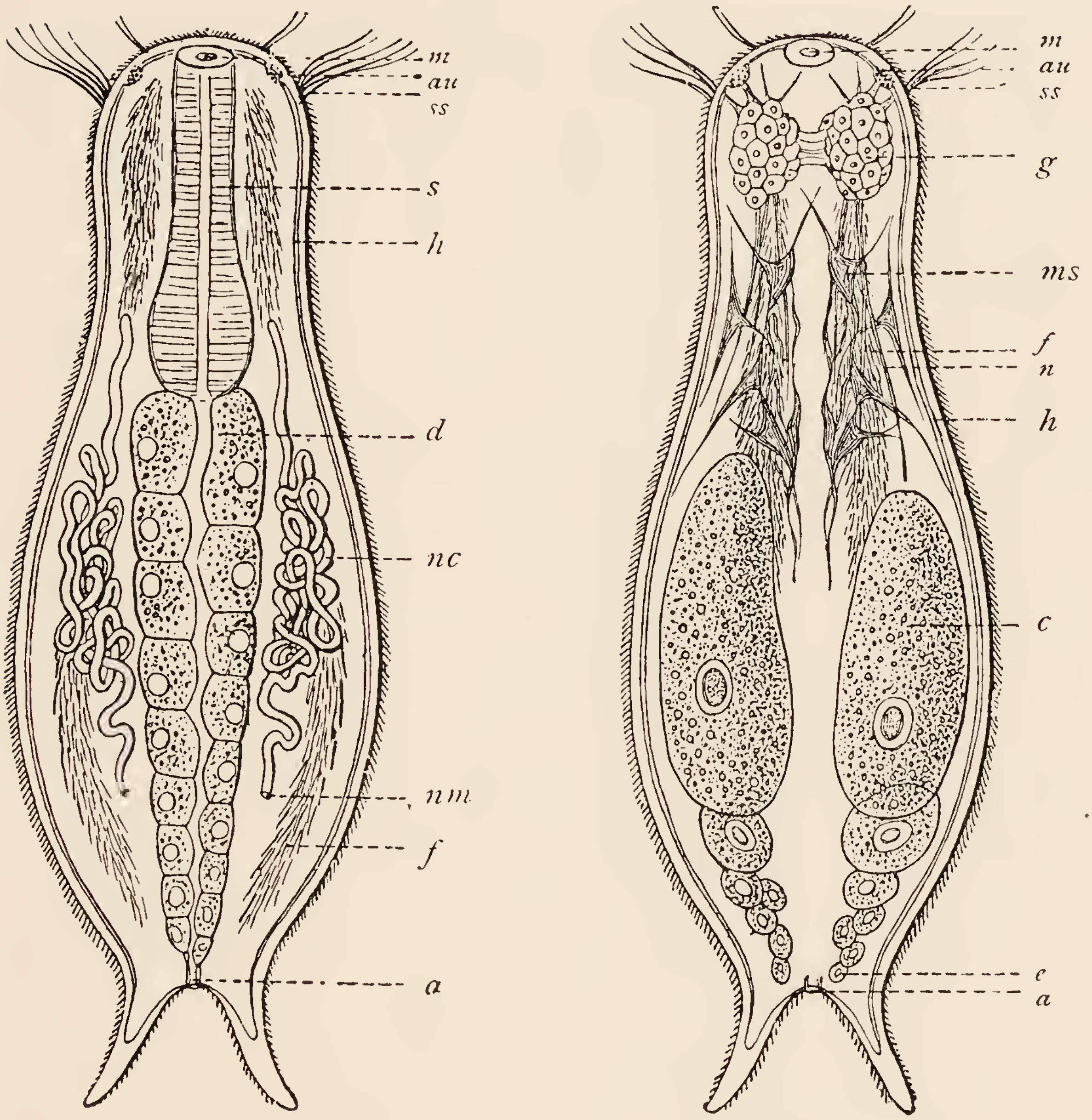


FIG. 110. FIG. 111.

FIGS. 110 and 111, Group VII., show two views of one of the wheel-worms, the chaetonotus, a rudimentary vermalian of the group gastrotricha. *m,* mouth; *s,* gullet; *d,* gut; *a,* anus; *g,* brain; *n,* nerves; *ss,* sensory hairs; *au,* eye; *ms,* muscular cells; *h,* skin; *f,* ciliated bands of the ventral surface; *nc,* nephridia; *nm,* their aperture; *e,* ovaries.

organism to be in quick communication with the outer world was one of those steps in development which added almost infinite power to the animal race. These special organs are the nervous system. At first the skin had to be the nervous system, because it was the only connection between the animal and its environment. From this simple beginning has developed the elaborate nervous system of all the higher animals, giving them their greater intelligence. Hence it is that intelligence, in its ultimate origin, is a branch of physics.

The nervous system arose as a division of labour, and is found as early as the sixth stage of our ancestors, the platodes.

After millions of years a strange new thing happened: a small string-like cord appeared in portions of these worm-like creatures. This cord was very small, and shorter than the body of the animal, and not permanent. Later an animal appeared in which this cord, now along the whole back of the animal, gave place to a structure afterwards to be known as the back-bone. Then we had a vertebrate animal called a fish. This creature had developed some small slits into gills, and was able to breathe the oxygen in the water. Here we have the beginning of the vertebrate class. When I meet with people whose chief difficulty in evolution is that the barrel-organ monkey never turns into an Italian organ-grinder on their front door-steps, I wish they would take up evolution at the stage where vertebrates originated. To find the real ancestors of fish would be an achievement.

When once the world had become decorated with the ornament of a vertebrate animal, it only required a few million years to accomplish all the rest. It was a long, chequered, and gory history; but it is a fairly plain history after that point.

A more recent upheaval of revolutionary matter

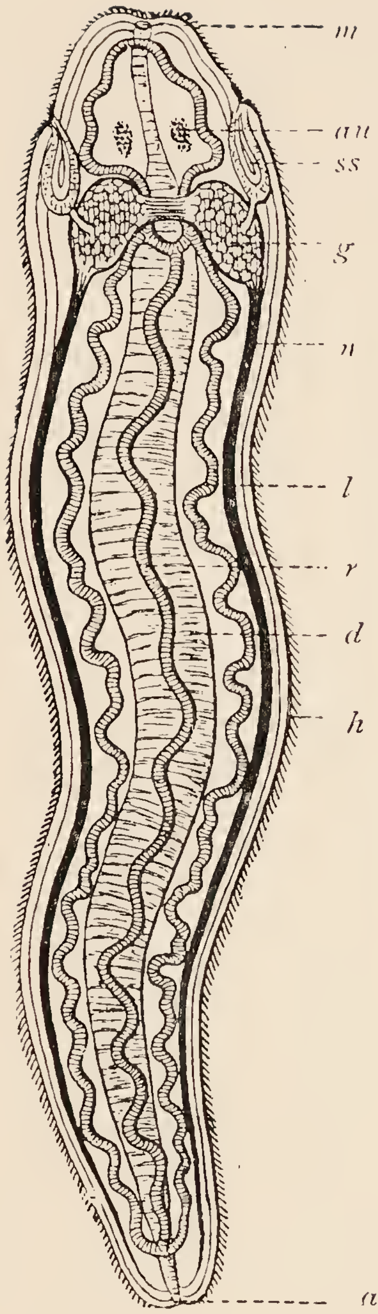

m
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FIG. 112.

For explanation see p. 128.

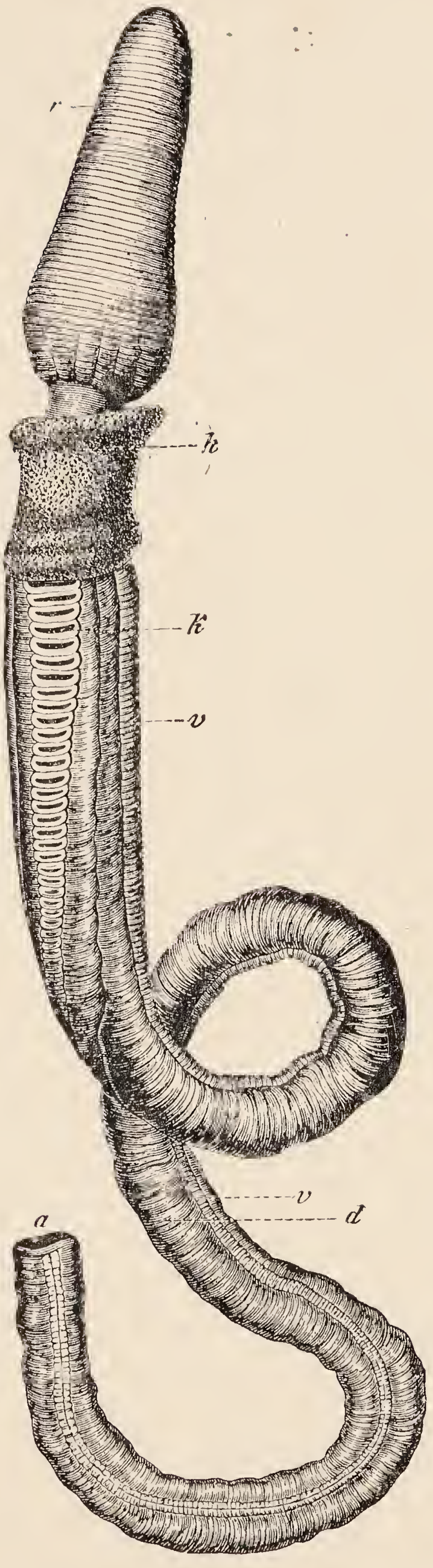

FIG. 113.

FIGS. 112 and 113, Group VII., show two examples of Snout-worms. Fig. 112, a simple nemertine. *m,* mouth; *d,* gut; *a,* anus; *g,* brain; *n,* nerves; *h,* ciliary coat; *ss,* sensory pits (head-clefts); *au,* eyes; *r,* dorsal vessel; *l,* lateral vessels. Fig. 113, a young enteropneust (balanoglossus, acorn-worm). *r,* acorn-shaped snout; *h,* neck; *k,* gill-clefts and gill-arches of the foregut in long rows on each side; *d,* digestive hind-gut, filling the greater part of the body-cavity; *v,* intestinal vein or ventral vessel, lying between the parallel folds of the skin; *a,* anus.

led this strange animal to leave the sea and live on land. Very gradually did this occur. It was a great discovery in economics when the creature developed lungs sufficiently to be able to extract its oxygen from the air; and the fact of moving on land transformed the fins of the fish into limbs, and there was the marvel of a four-footed creature—a quadruped.

Perhaps the next stage of deepest interest to us is that at which the quadruped took to walking on two feet, and by this turned his fore-feet into hands. This gave us the machine-making animal, and was the origin of houses and cities, music and art.

According to Professor Lester F. Ward, there came a remarkable revolution in the relations of the sexes at a later stage. Formerly, in all cases the female had *chosen* the male before marriage, and, by choosing the fiercest and strongest and biggest, she created a more powerful animal than herself; and at last this male animal, somewhere on the main line of the development of mankind, took the power of choice from the female, and so man became the chooser and by this determined marriage and altered the whole order of sexual selection. (And a pretty muddle he made of it.)

In following the pedigree of man it is not necessary that much more should be added, beyond the names of the pictures. It seems impossible that any subject can be of deeper interest to the human race than the knowledge of the slow march, through millions of years, which shows how man came upon the earth.

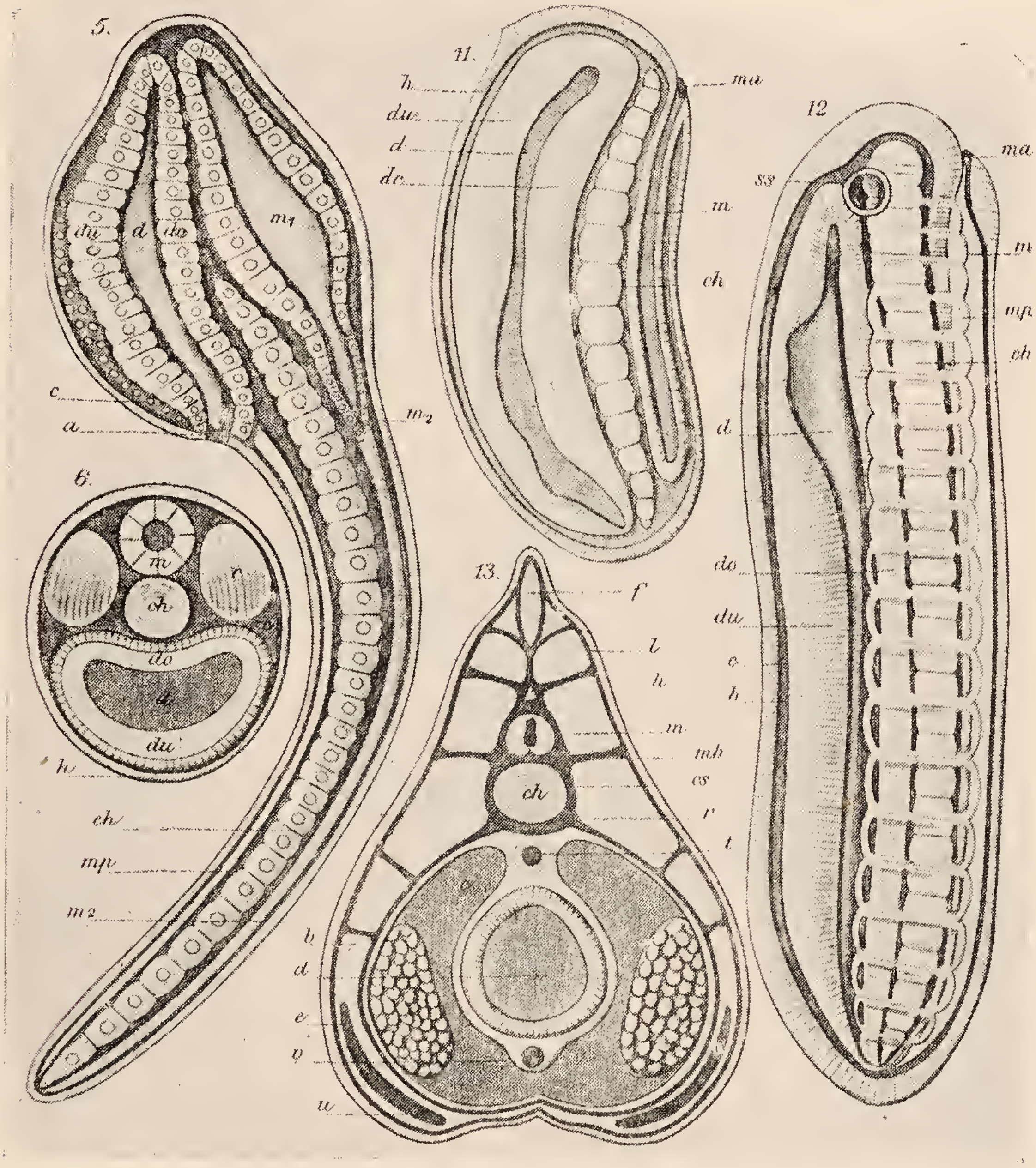
5.
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FIG. 114, Group VIII.—Larva of the Ascidian and larva of the Amphioxus show some striking likenesses, which are of great importance, as the amphioxus is so clear a link in the history of vertebrates. 5, the free larva of the ascidian. Between the medullary tube *(m)* and the alimentary canal *(d)* the chorda *(ch)* passes and goes the whole length of the tail to the tip. 6 is a transverse section of 5. The section is just the same as that of the amphioxus larva *(11* and *12)*. *11* is the young larva of the amphioxus ; *m, d,* and *ch,* as in 5. *12* is an older larva of the amphioxus, with letters meaning the same ; *ma* is the opening of the medullary tube at its anterior end.

We must remember (1) that no one pretends to show the exact ancestor of this or that race of men; (2) that man evolved through various groups of animals, and to these groups we must turn; (3) that none of the *living* groups of animals are to be taken as the *unaltered* ancestors of man. With

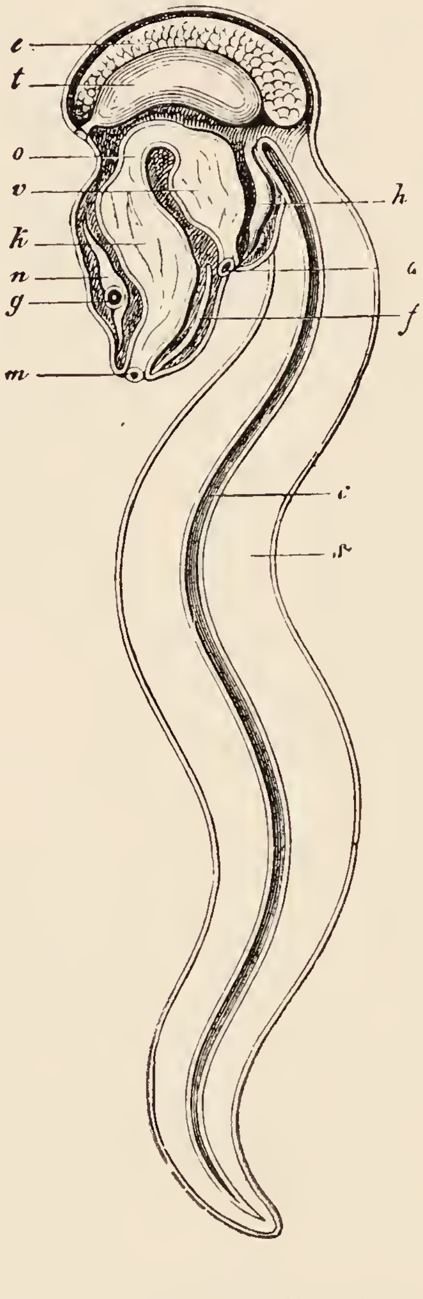


FIG. 115, Group VIII.—An Appendicaria (copelata), seen from the left. *m,* mouth; *k,* branchial gut; *o,* œsophagus; *v,* stomach; *a,* anus; *n,* brain (ganglion above the gullet); *g,* auditory vesicle; *f,* ciliated groove under the gills; *h,* heart; *t,* testicles; *e,* ovary; *c,* chorda; *s,* tail.

these precautions we may follow the pictures in this chapter as a fairly approximate record of the stages of animal development which finally resulted in human beings.

In the list, the amphioxus (Fig. 114), or lancelet, is of the utmost interest as showing how the vertebrates may have arisen from the invertebrates. Mr. Arthur Willey is an authority on this subject. He says: "For the present we may conclude that the proximate ancestor of the vertebrates was a free swimming animal, intermediate in organisation between an ascidian tadpole (Fig. 114) and amphioxus, possessing the dorsal mouth, hypophysis, and restricted notochord of the former; and the myotomes, cœlomic epithelium, and straight canal of the latter. The ultimate or primordial ancestor of the vertebrates would, on the contrary, be a worm-like animal whose organisation was approximately on a level with that of the bilateral ancestors of the echinoderms." He says that "the larvæ of ascidians are the nearest existing relatives of the amphioxus."

Another most interesting group is the marsupials. These small pouched animals (Figs. 128–134) are well represented. They were so numerous and so early in the history of mammals that there is little room to doubt that, as a group, they are on the main ancestral line, though the large pouched animals now existing, as kangaroos, have probably developed on a side line.

The group of insectivors (insect-eaters) is no less interesting, and the step from them to the lemurs is easy.

The platyrrhine apes are of no value to us *ancestrally,* but a few are given to help us to realise somewhat the extraordinary variations shown by

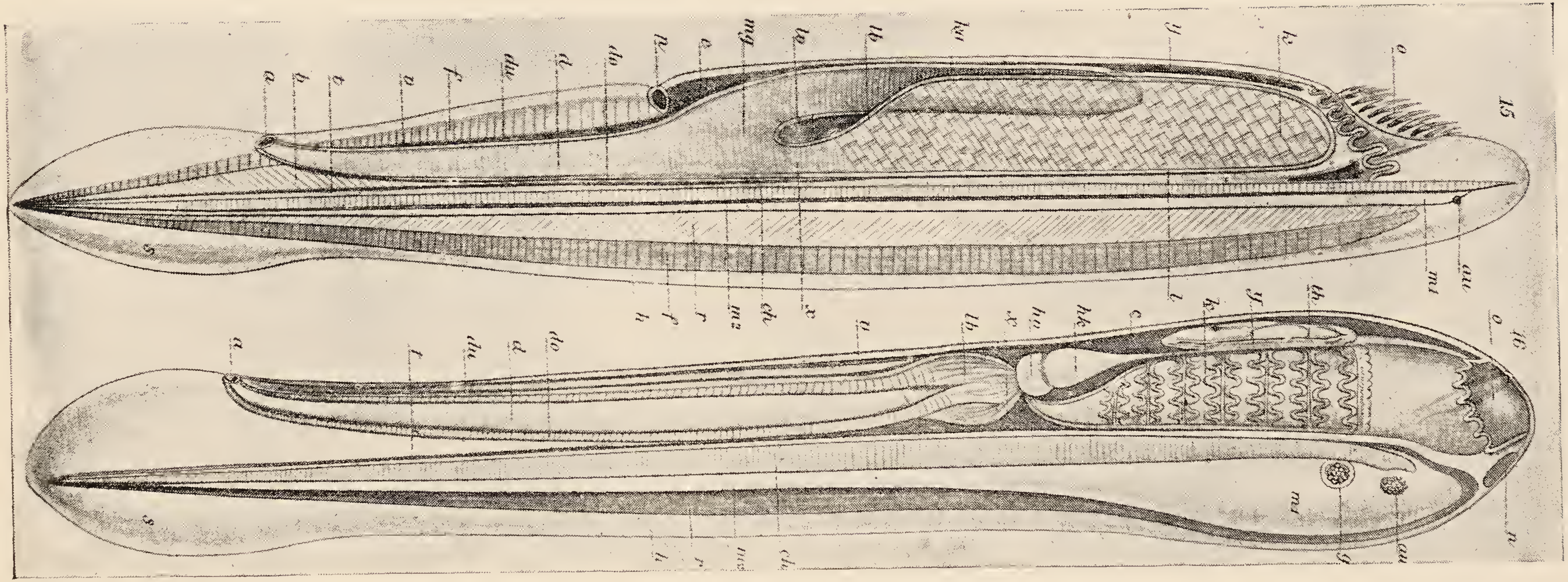


FIG. 116, Group IX.—*Au*, eye; *a*, anus; *b*, ventral muscles; *c*, mantle cavity; *ch*, chorda; *cl*, cloaca; *cs*, chorda-sheath; *d*, alimentary canal (gut); *do*, dorsal wall of gut; *du*, ventral wall of gut; *e*, ovary; *en*, endostyle; *f*, fin border; *g*, auditory vesicle; *h*, horny plate; *hd*, testicles; *hk*, ventricle of heart; *hv*, auricle of heart; *hz*, heart; *i*, ova; *k*, gills; *ka*, branchial artery; *l*, corium (cutes); *lb*, liver; *lb*^{1}, anterior end of liver; *lv*, hepatic vein; *m*, medullary tube; *m*^{1}, cerebral vesicle; *m*^{2}, spinal marrow; *ma*, anterior opening of *m*^{2}; *mb*, muscular ligaments; *mg*, stomach; *mh*, mouth cavity; *mp*, muscle plate; *mt*, mantle; *n*, nose; *o*, mouth; *p*, ventral pore; *q*, ejection opening (cloaca); *2*, dorsal muscles; *s*, tail fin; *sl*, sperm duct; *sm*, its aperture; *ss*, sense organs; *t*, aorta; *th*, thyroid gland; *u*, lateral canal of mantle folds; *v*, sub-intestinal vein; *x*, limit of branchial gut and hepatic gut; *y*, gullet-groove.

the two large groups of apes after they left the common ancestors.

New evidence has been offered in support of the view that the down-nosed (catarrhine) apes, or Old-World apes, are blood-relatives of man.

In the *Royal Natural History* (p. 38) we read: "What zoologists do contend for is that, supposing some kind of evolution to be the true explanation of the origin of animals—and all available evidence indicates that it is so—man is so intimately connected, so far as his bodily structure is concerned, with the higher apes that in this respect, at least,

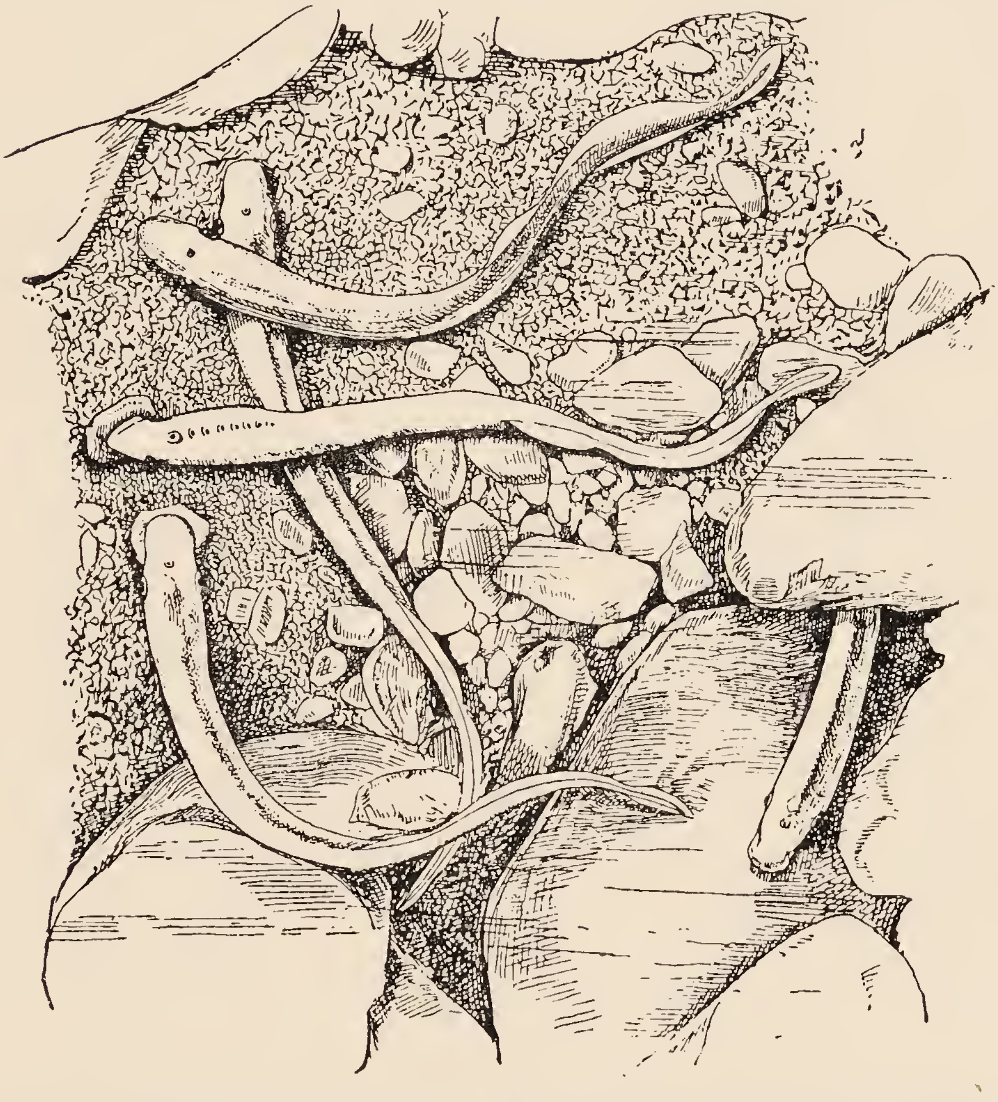


FIG. 117, Group X.—Lampreys (petromyzon Wilderi) in the act of spawning. They are also called cyclostomes, the round-mouthed. (See Figs. 108 and 109, Part I.)

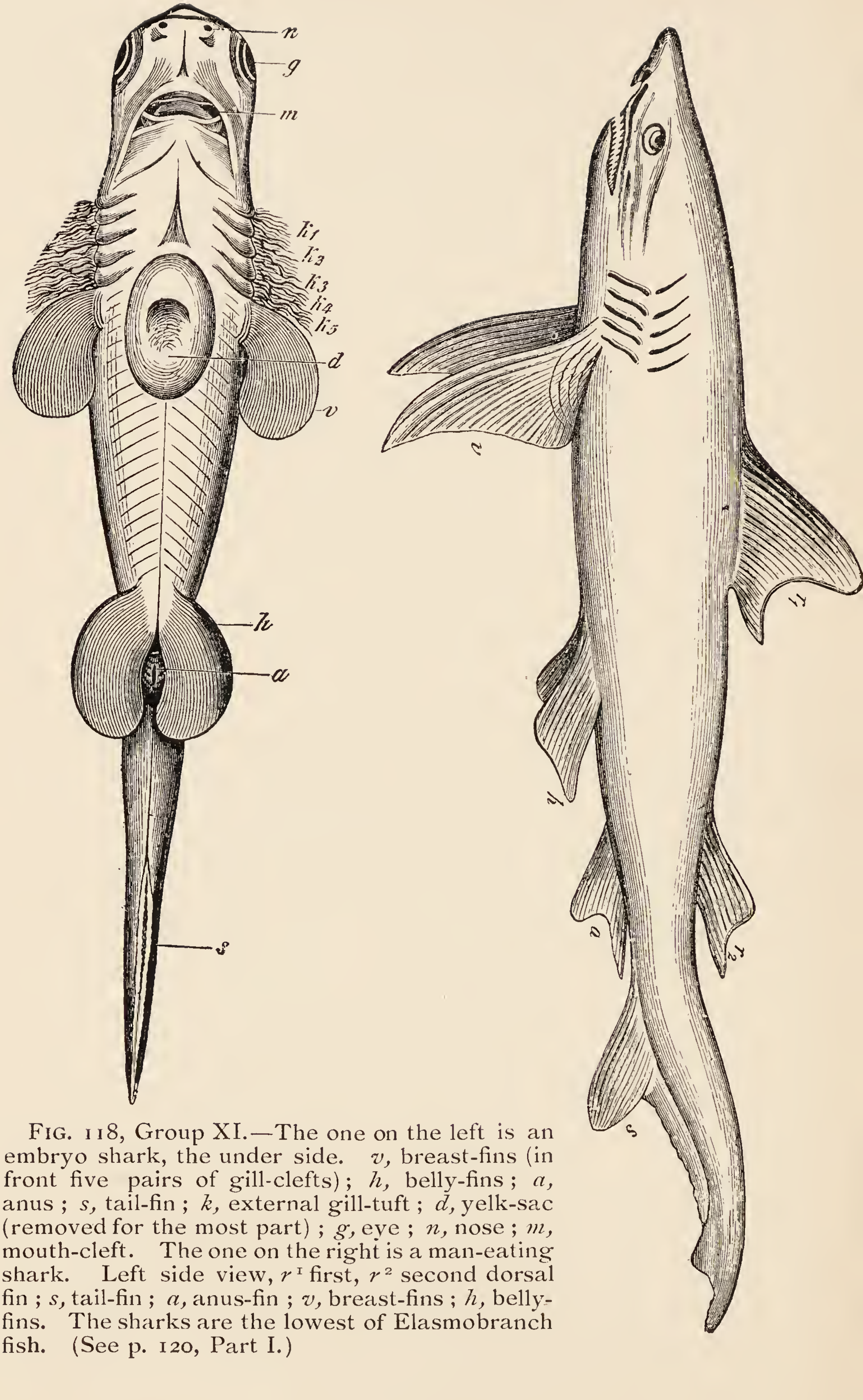


FIG. 118, Group XI.—The one on the left is an embryo shark, the under side. *v,* breast-fins (in front five pairs of gill-clefts); *h,* belly-fins; *a,* anus; *s,* tail-fin; *k,* external gill-tuft; *d,* yelk-sac (removed for the most part); *g,* eye; *n,* nose; *m,* mouth-cleft. The one on the right is a man-eating shark. Left side view, r^1 first, r^2 second dorsal fin; *s,* tail-fin; *a,* anus-fin; *v,* breast-fins; *h,* belly-fins. The sharks are the lowest of Elasmobranch fish. (See p. 120, Part I.)

he cannot but be considered to have had a similar origin.

“And, on this view, both man and the man-like apes are regarded as diverging branches descended from a common ancestor, long since extinct, and as much unlike any living ape as such apes are unlike

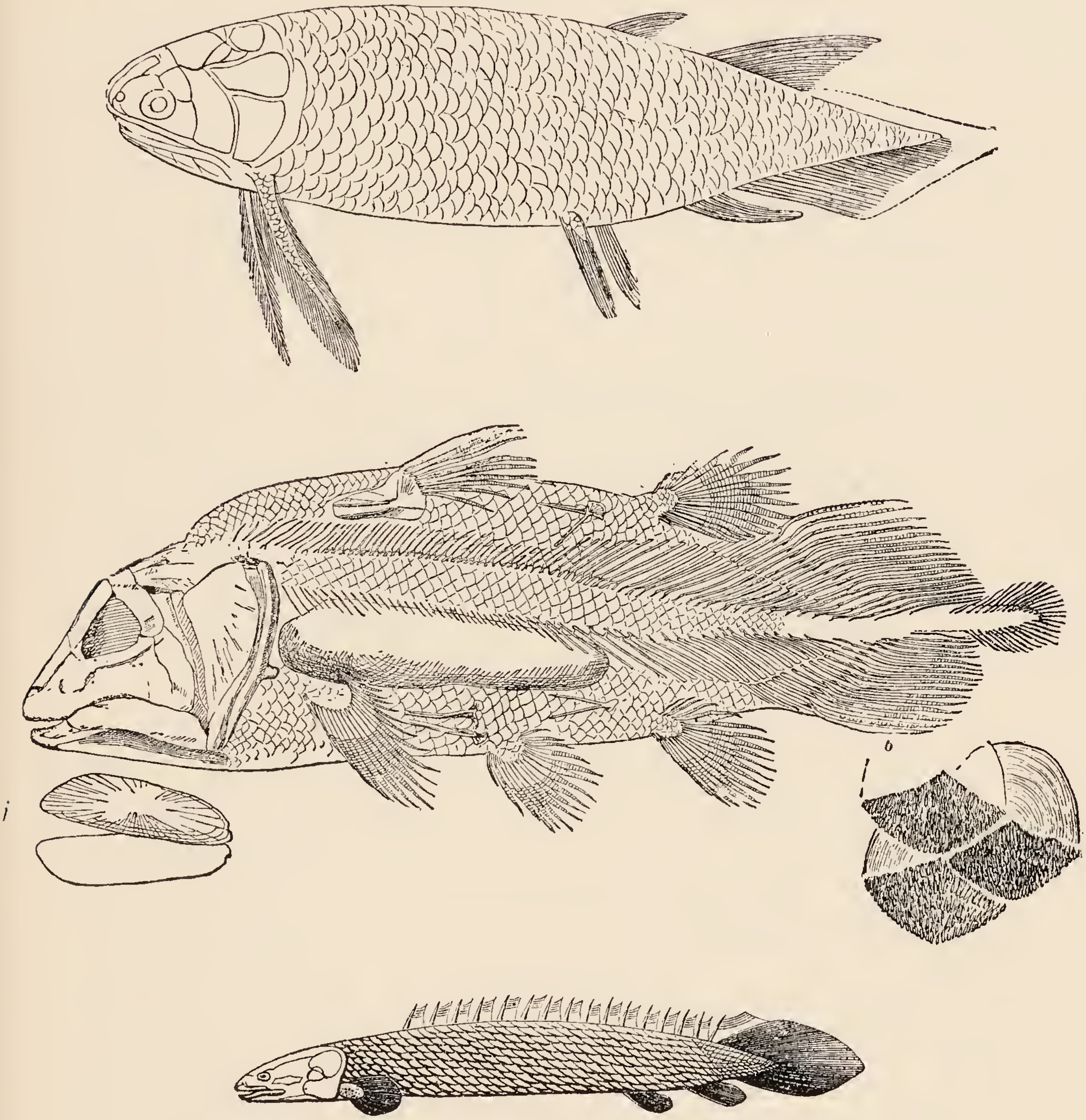


FIG. 119, Group XII.—The top one is a Devonian crossopterygius. The middle one is a Jurassic crossopterygius. *j*, jugular plates; *b*, three-ribbed scales. The bottom one is a living crossopterygius—the polypterus.

man himself. The gorilla and chimpanzee are presumed to be descended from apes which diverged from the common ancestral stock, *subsequently* to the *assumption* of the human attributes of seventeen vertebræ between the sacrum and neck, and the *loss* of the central bone in the wrist."

It is a point of remarkable interest to have this evidence of the bones that man travelled, at any rate, some distance from the common ancestors, in company with the gorilla and the chimpanzee.

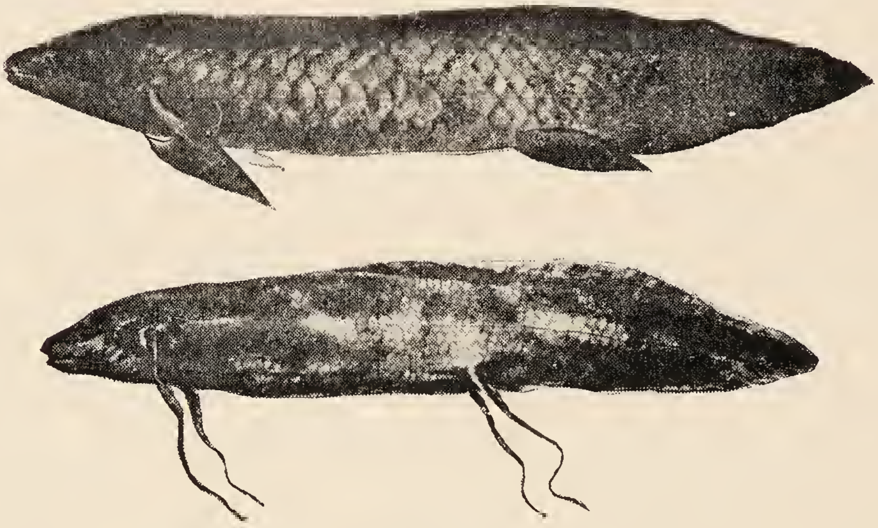


FIG. 120, Group XIII.—Dipneusts. Above is the Burnett salmon, beneath is the mud-fish.

But there is more striking evidence of our blood-relationship with the anthropoid apes. This evidence has been put before the world by Professor Metchnikoff, in his book, *The Nature of Man,* pp. 49–54.

Stated baldly and briefly, it is this: If blood obtained from any species of animal be injected into the veins of another animal of the *same species,* no results of any kind are to be observed. The injected drops of blood find themselves at home, and their corpuscles mingle with those of the second animal's own blood without any ill results.

"It is found, however, that very striking results follow the injection of blood from an animal of one species into the veins of an animal belonging to *another* species, as from a cat to a dog."

The red blood corpuscles of the second animal's blood dissolve rapidly. This result is due to the presence in the fluid of the blood of any animal of certain substances which are cell-dissolvers (cytolysins). These cytolysins have no bad effect upon the cells of the blood in which they naturally occur, "or upon the cells of the blood of any animal that belongs to the same species." The blood of any

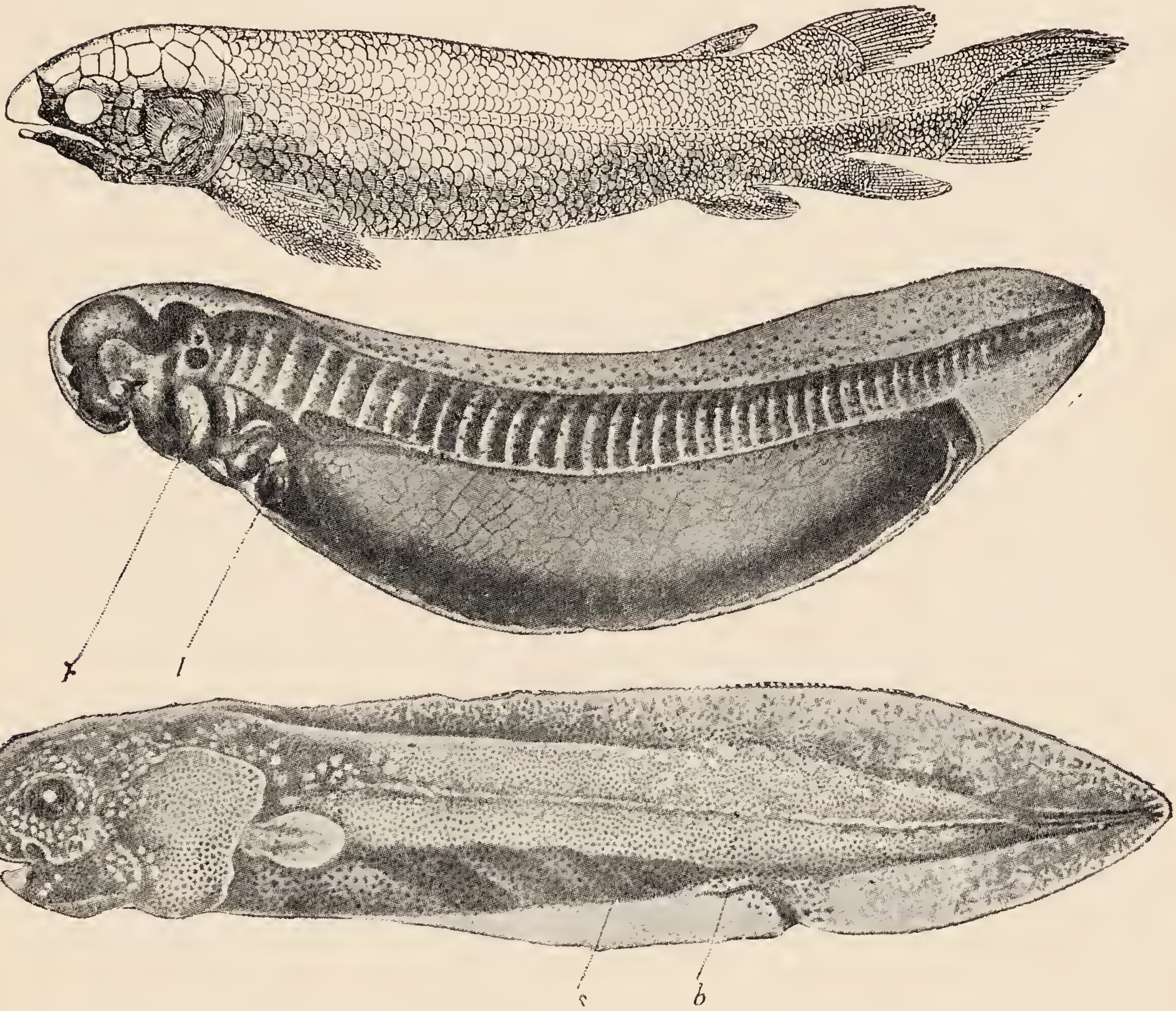


FIG. 121, Group XIII.—The top one is a fossil, the middle a young ceratodus, shortly after issuing from the egg; the bottom ceratodus a little older. *s,* spinal fold of gut; *b,* rudimentary belly-fin.

kind of dog will not affect the blood of any other kind of dog.

But if there is a *difference of species,* the cell-dissolving action is found to occur. Here, then, is a new subtle test for blood, which can be used in criminal cases in courts of law. This new test has been applied to man's relationship with other animals. If human blood is mingled with the blood of the *lower* apes, it has a bad effect on the latter, and there is a dissolving of blood cells, for the human cells are not at home there.

But this does not happen when human blood is mixed with the blood of the *anthropoid* ape. In this case there is no dissolving of the blood-cells. They are so nearly identical that they agree as if they were animals of one species. No wonder this is claimed as a new proof of man's close blood relationship with the anthropoid ape.

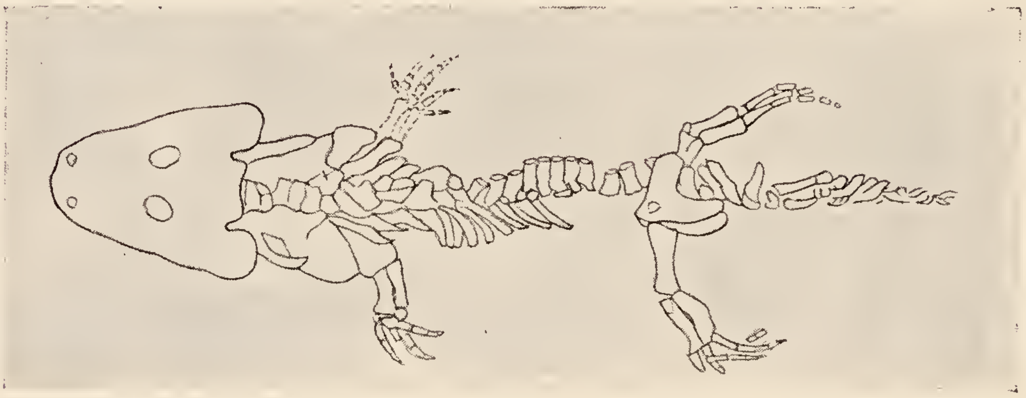


FIG. 122, Group XIV.—Skeleton of Actinodon, a very early amphibian, from the Permian strata.

We may now try to reconstruct the pedigree of man from the dawn of life to our highest civilisation.

GROUP I.

Group I. contains only moners, vegetable and animal. They are the simplest organisms known to us. The whole body is a simple particle of plasm or protoplasm, with no structure.

GROUP II.—AMŒBÆ.

The next stage to the simple cytode forms, which we have seen in the moners, is the simple cell. It marks a distinct step in the genealogy of man, and indeed in that of all animals, as is well seen in the amœba. The structureless plasm of the moner divides into two substances—the outer softer part (the mass of the body) and the inner firmer part, the nucleus.

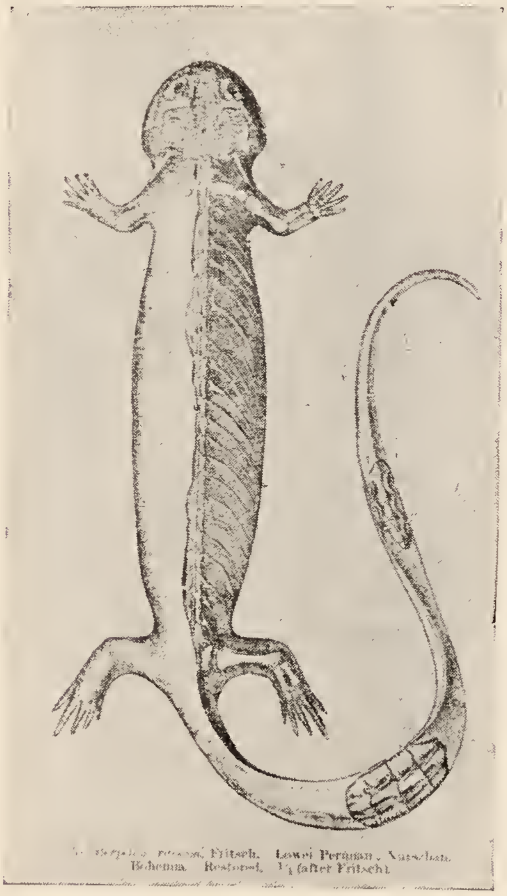

[illegible] Fritsch. Lower Permian, [illegible] Bohemia. Restored. [illegible] (after Fritsch).

FIG. 123, Group XIV.—Keraterpeton, from Lower Permian.

GROUP III.—MORÆADS.

This group is marked by the enormous differentiation that the cells have become associated. We no longer are confined to forms of one cell only, but we have reached the dawn of those marvellous organisms called multicellular.

GROUP IV.—BLASTÆADS.

The moræads are practically solid globes of amassed cells; but the blastæads secrete a watery fluid inside their globular body, and the cells rise to the surface of it. We thus have a hollow sphere, the wall of which is composed of a single layer ot cells. The layer of cells is called the *blastoderm,* and the sphere itself the *blastula.* The planula (Fig. 105) is an animal that shows this arrangement.

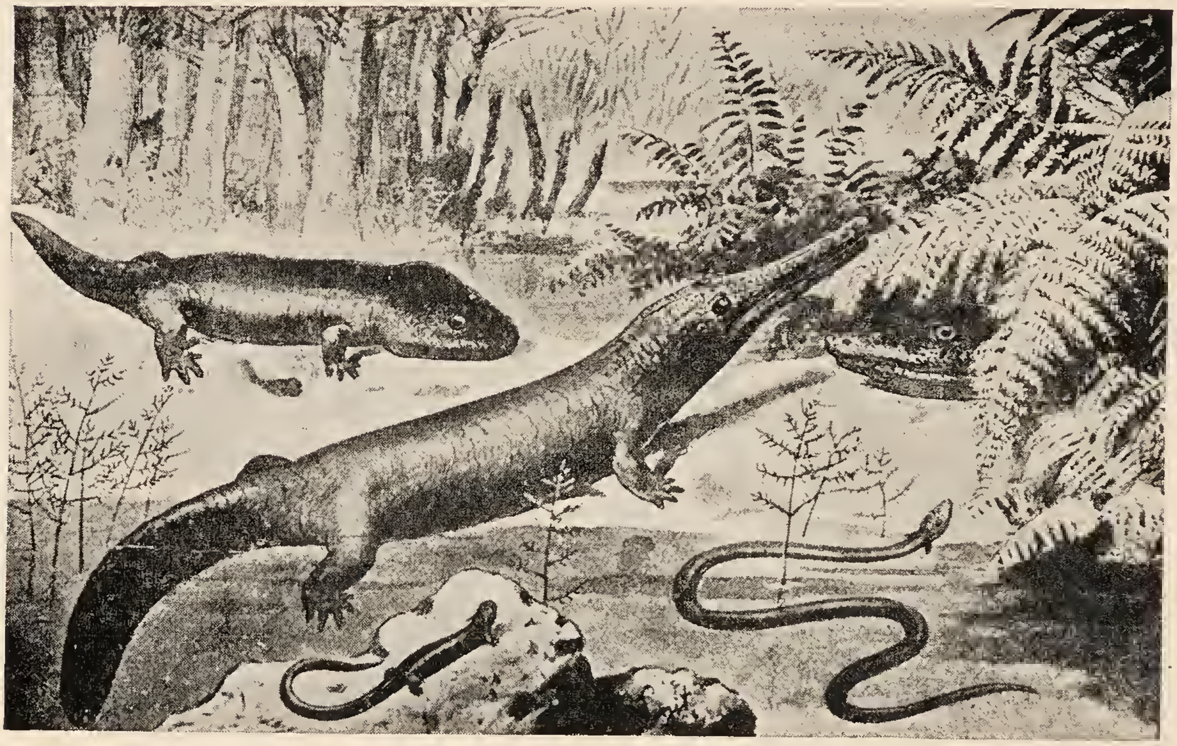


Fig. 124, Group XIV.—Group of Amphibians of the coal-forest period. The big one in the centre is the archægosaurus; the one above actinodon; the one immediately below keraterpeton; the snake-like creature is the dolichosoma; the head is loxomma.

GROUP V.—GASTRÆADS.

After the cell colonies had grown into *hollow* spheres, another great step was taken by a very gradual process. One half of the ball sank in upon the other half, so that two layers of cells were formed ; this gave an inner and an outer layer, and by degrees new functions were taken on by each layer. All animals had acquired an inner and an outer existence !

The creatures of this type are gastræads—*gaster,* a belly.

We are now able to consider our worm-like ancestors.

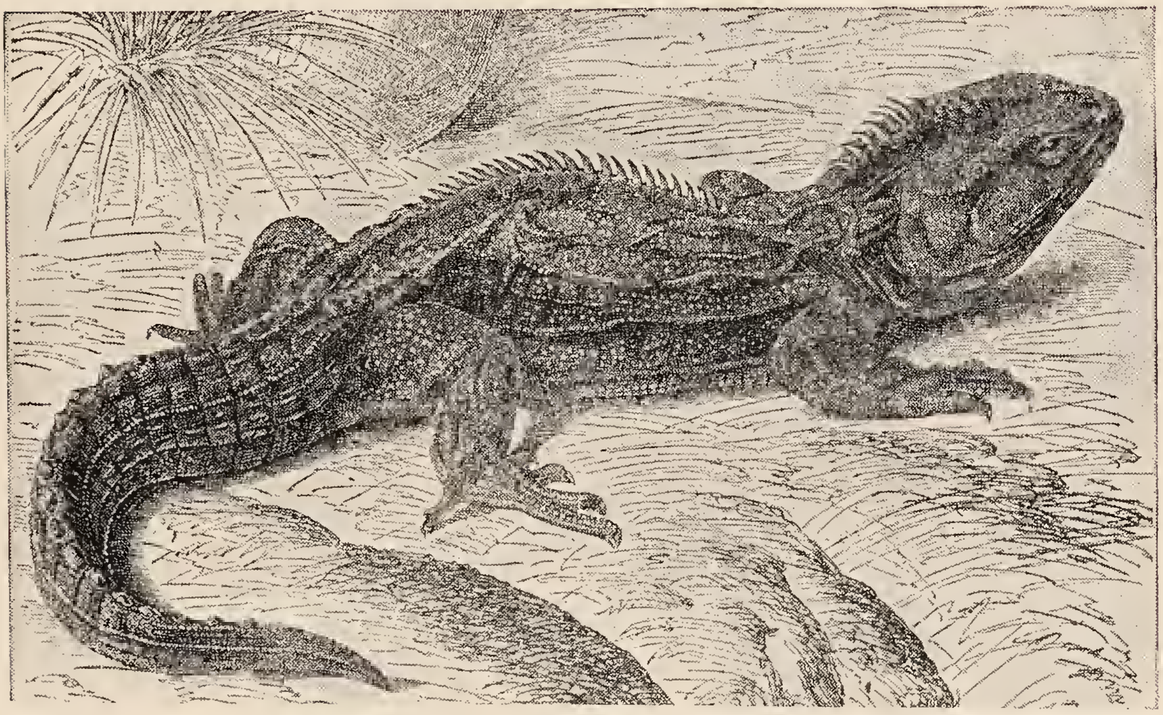


FIG. 125, Group XV.—Sphenodon punctatus (see Part I., p. 133).

GROUP VI.—PLATODES.

There are supposed to be four classes of platodes —the two *free-living* classes of the primitive worms (platodaria) and the coiled worms (turbellaria), and two *parasitic* classes (suctorial worms and tape worms). We are only concerned with the first two.

Haeckel says : "The Turbellaria (Fig. 108) are still represented by a number of different forms, in both fresh and sea water. The oldest of these are the very rudimentary and tiny forms that are known as 'rod-gut animals' (Fig. 109), on account of the

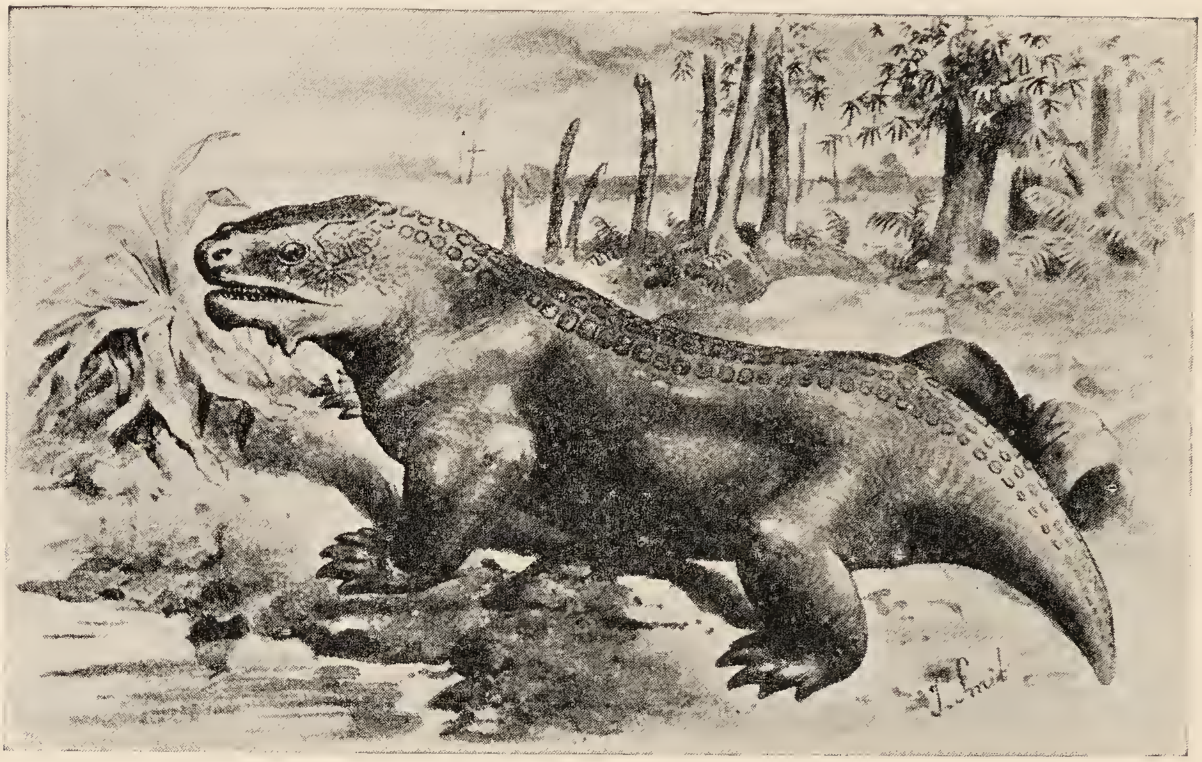


Fig. 126, Group XV.—The Pareiasaurus (see Fig. 75, Part I.), restored.

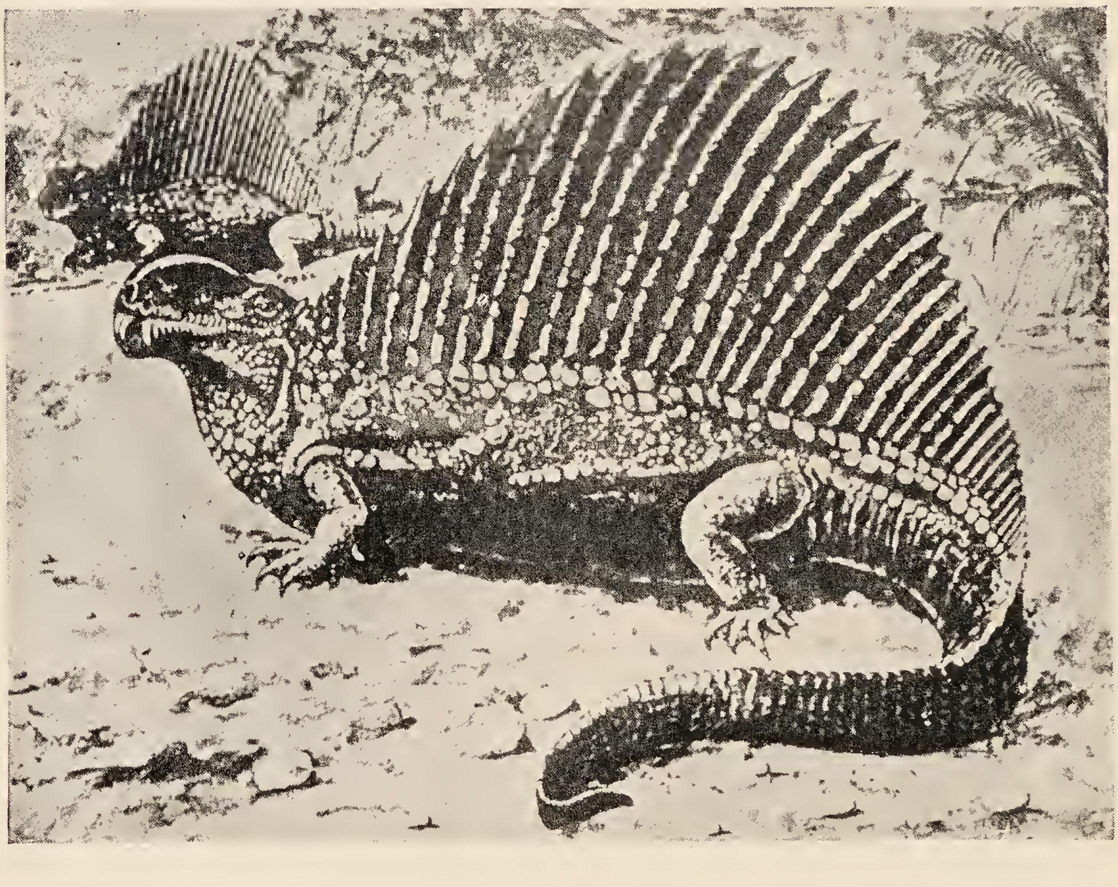
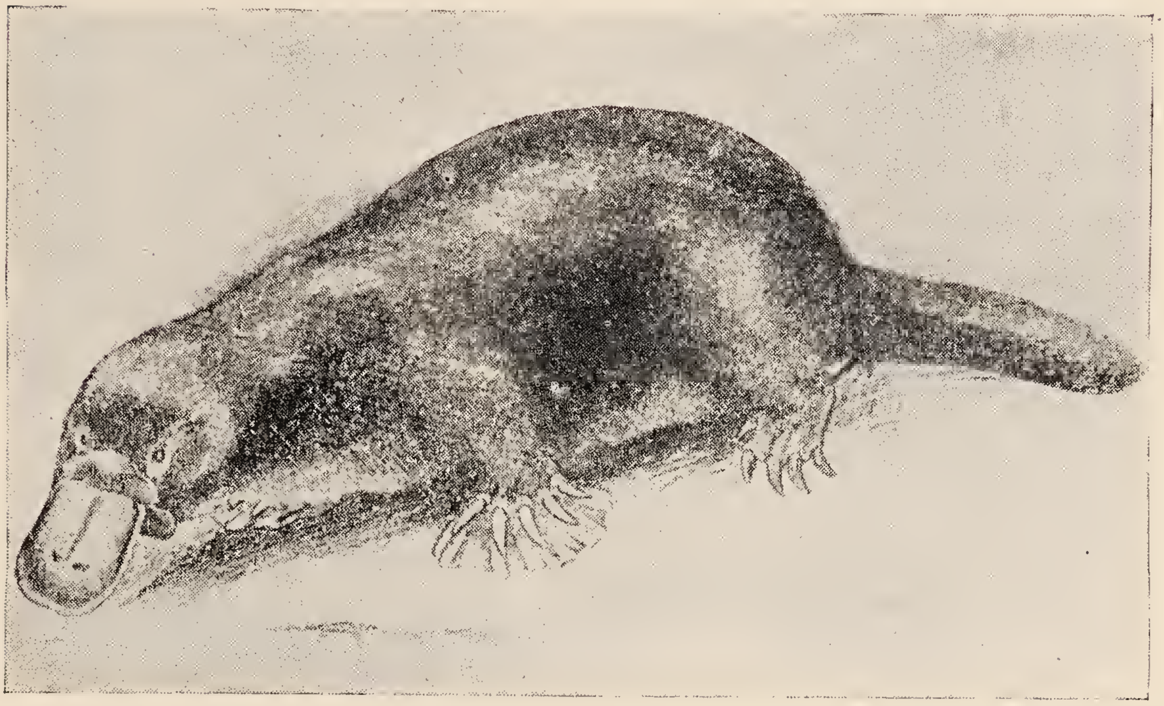


Fig. 127, Group XV.—Probable appearance of the Theromorph Reptile, Dimetrodon.

I.



II.

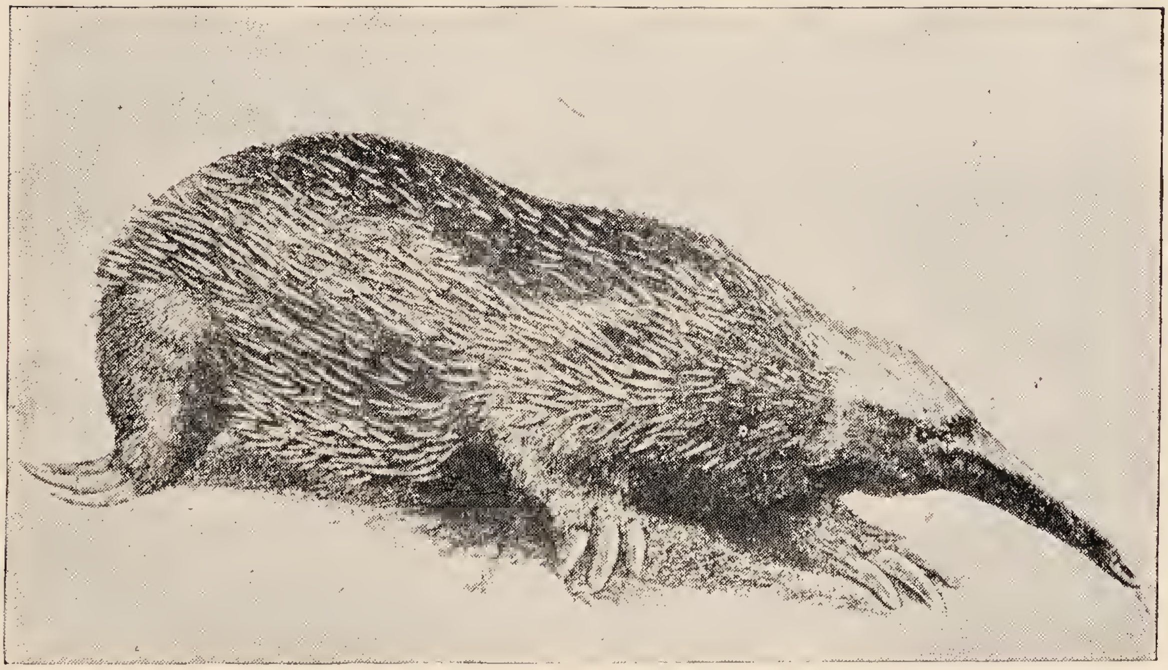


FIG. 128, Group XVI., shows the two surviving specimens of this Group. I. is the Duck-bill, II. the billed hedgehog (echidna hystrix). They are in some points like reptiles, birds, and mammals. (See pp. 143–145, Part I.)

simple construction of their gut; they are, as a rule, only a few millimetres long, and of a simple oval or lancet shape."

Haeckel assumes "that the oldest and simplest turbellaria arose from platodaria, and these directly from bilateral gastræads."

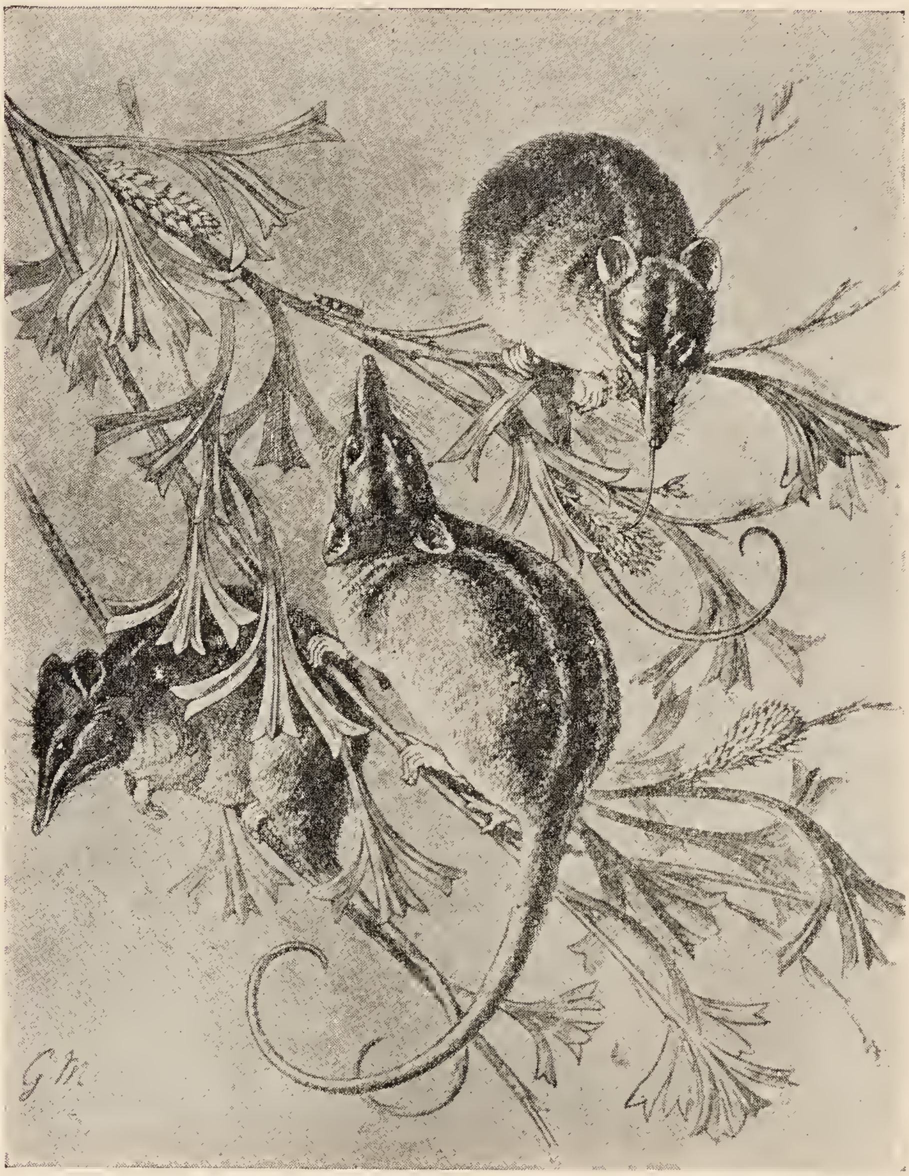


FIG. 129, Group XVII.—The Long-snouted Phalanger.

GROUP VII.—VERMALIA.

The next great step is one of much difficulty. We come to the group of worms (vermalia or

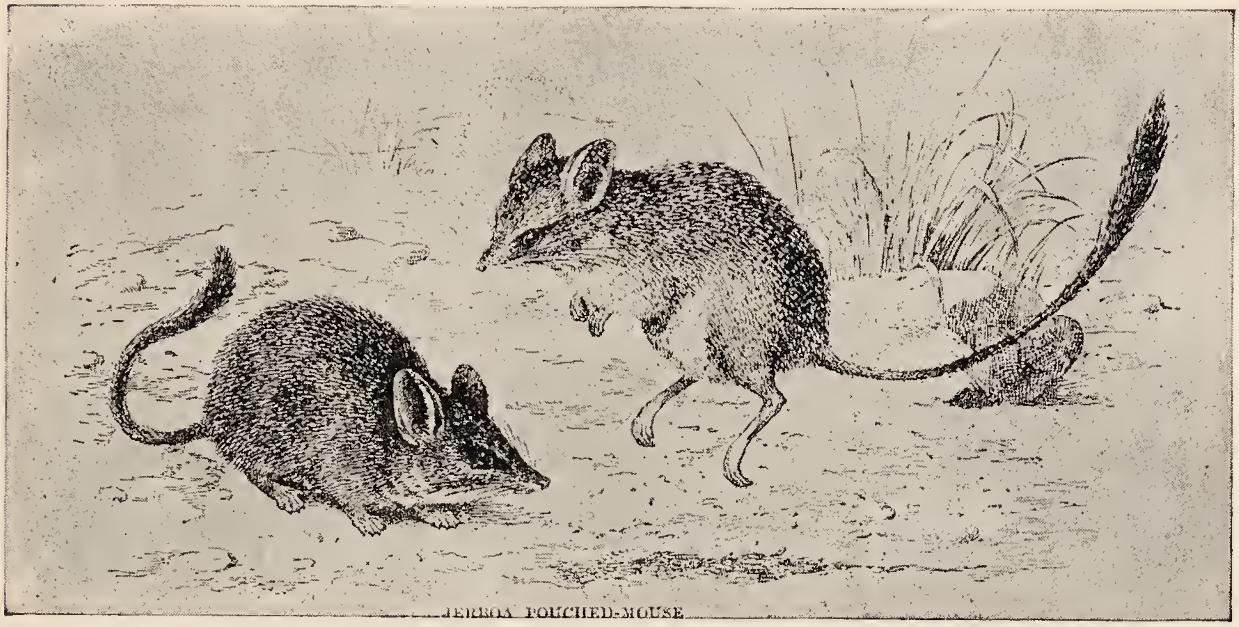

JERBOA POUCHED-MOUSE

FIG. 130, Group XVII.—The Jerboa Pouched Mouse.

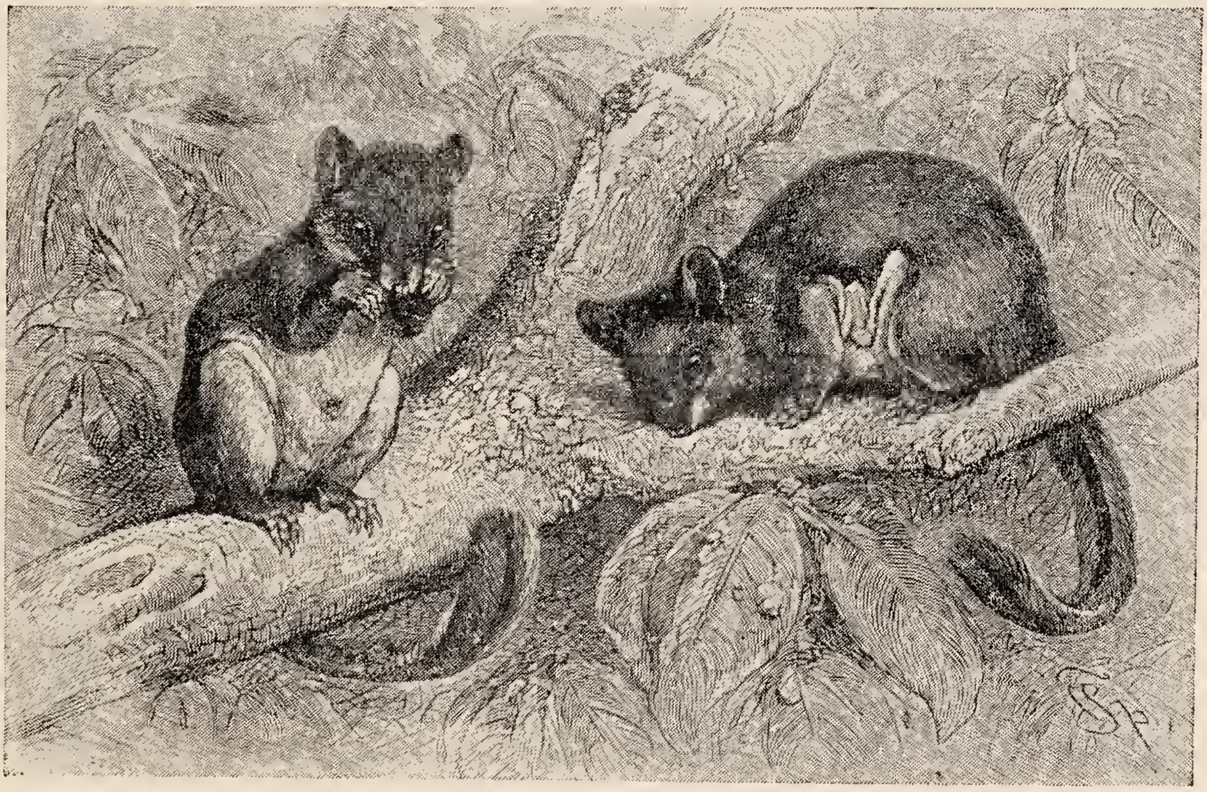


FIG. 131, Group XVII.—Pigmy Flying Phalanger.

vermes). There are four classes, two of which do not concern us in ancestry ; but two are of great importance—viz., the wheel-worms (rotatoria) and the snout-worms (rhyncocœla).

If these gastrotricha (Figs. 110, 111) can be regarded "as direct transitional forms from the turbellaria to the rotifers," they help us over a great difficulty.

Fig. 132, Group XVII.—Common Opossum.

The second class of this group, the snout-worms, are not so closely related to the platodes.

The acorn-worm (Fig. 113) is of the highest value in helping us to see how the chordate (vertebrate) class arose. It seems to be a survivor of the ancient gut-breathing vermalia from which the chordate animals have descended.

There is a very close connection between the

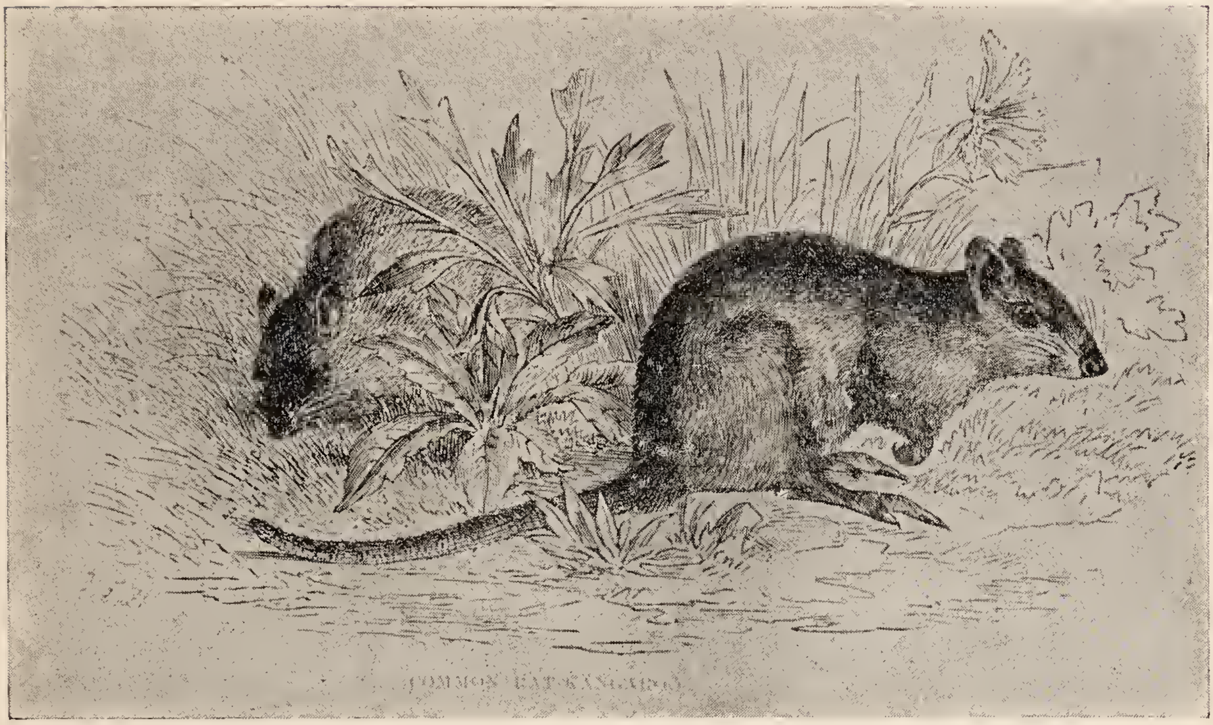

COMMON RAT-KANGAROO

FIG. 133, Group XVII.—Common Rat-Kangaroo.

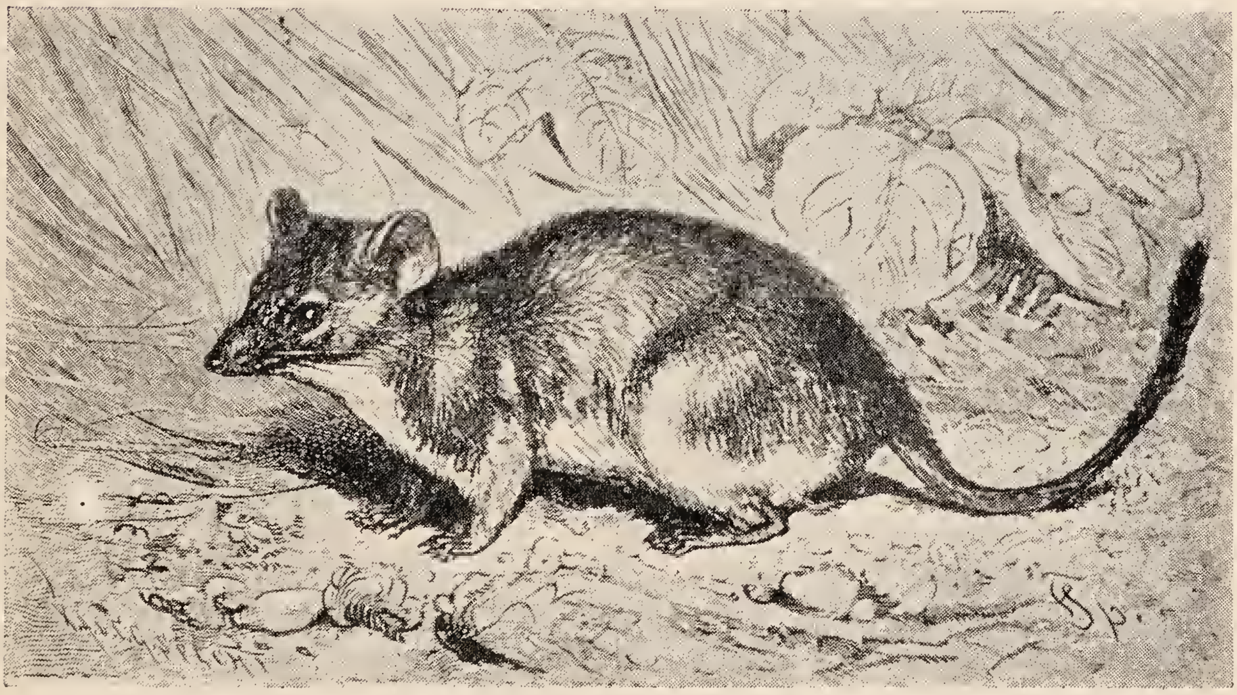


FIG. 134, Group XVII.—Yellow-footed Pouched Mouse.

young acorn-worm and the copelata (Fig. 115), and both are closely related to the amphioxus.

GROUP VIII.—PROCHORDONIA.

Many of the relationships betwixt these animals are only to be seen by taking the *young* forms.

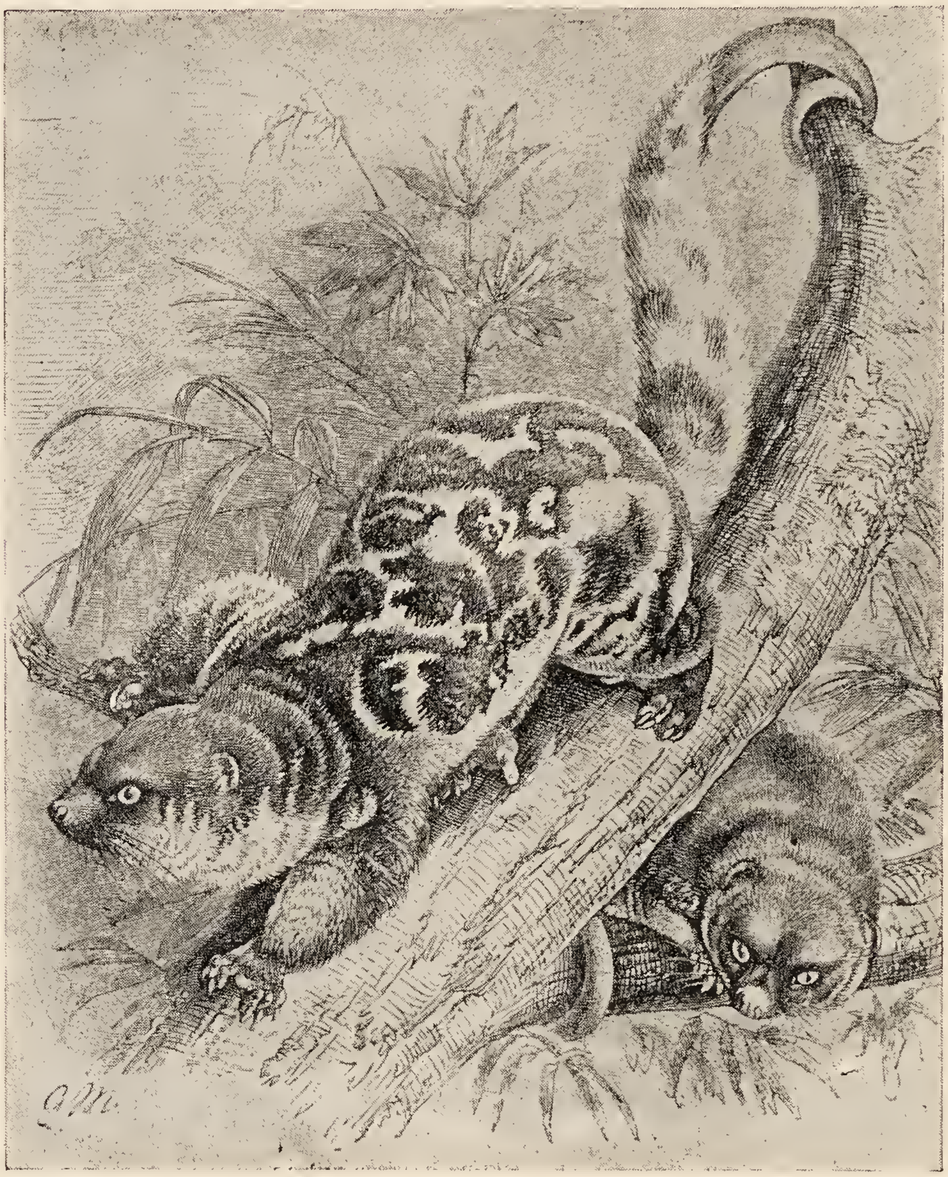


FIG. 135, Group XVII.—The Spotted Cuscus.

Animals fully grown often acquire their own distinctive features to such a degree that we fail to recognise their relationships to other groups.

Some ascidians (tunicates) remain throughout life at the stage of development reached by the tailed ascidian-larva. These are the copelata (Fig. 115). "They are the only living vertebrates that have throughout life a chorda dorsalis and a neural string above it." The latter is equivalent to the medullary tube.

This Group VIII., with its name prochordonia, which simply means before-the-chordates, is an important link, for, if we carefully consider Figs. 114 and 115 and compare them with the tadpole-stage of the frog, we shall see remarkable points of similarity. In Fig. 114 we see the great similarity between the larva of the ascidian and the amphioxus.

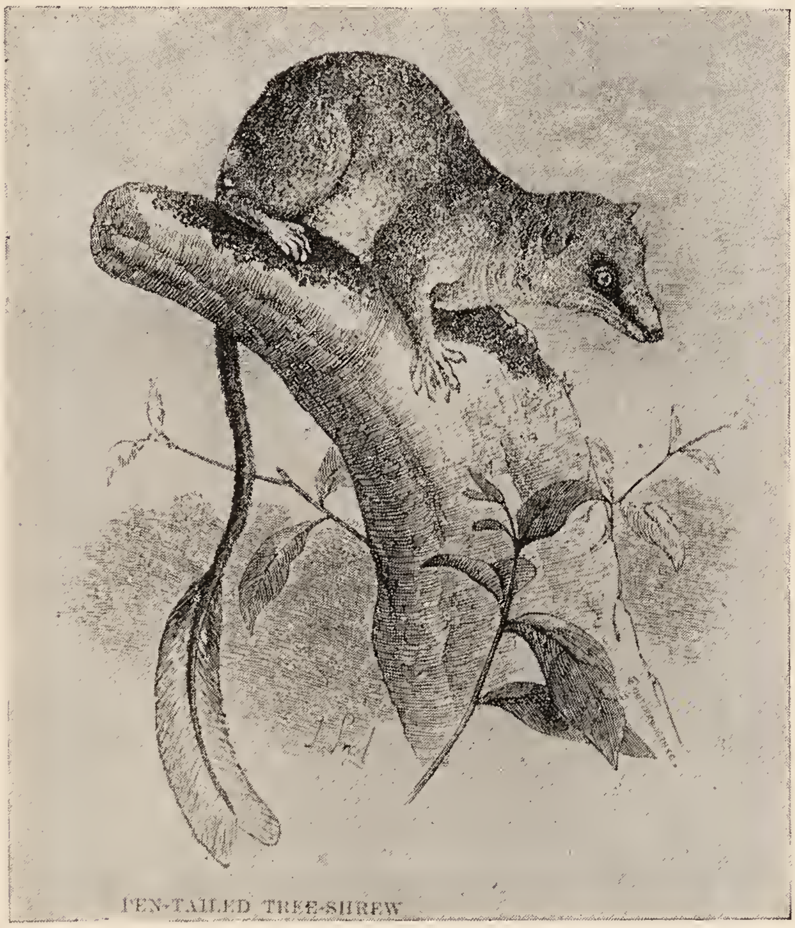


FIG. 136, Group XVIII.—Pen-tailed Tree-Shrew.

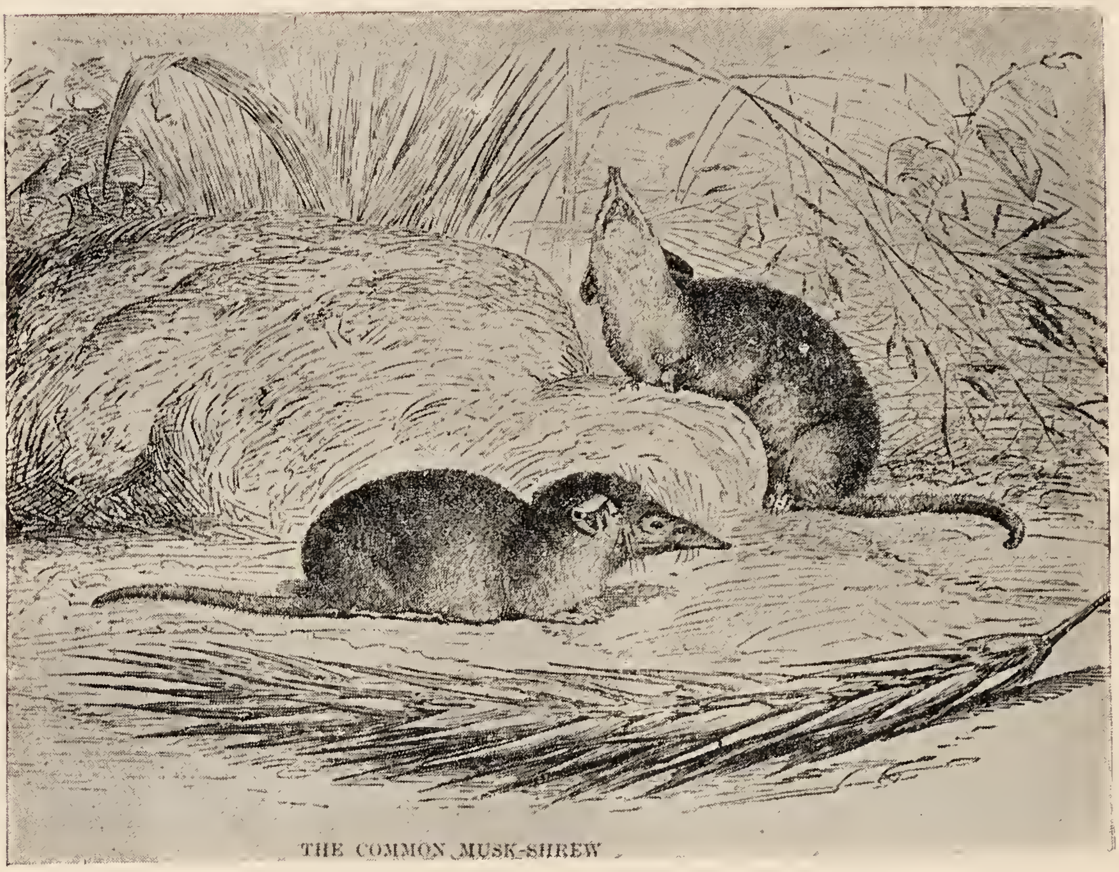

THE COMMON MUSK-SHREW

FIG. 137, Group XVIII.—The Common Musk-Shrew.

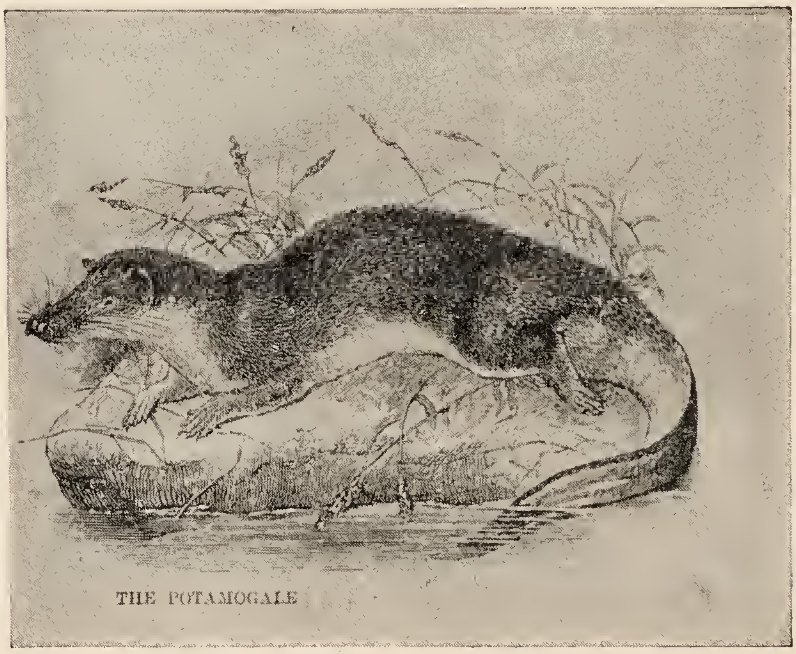

THE POTAMOGALE

FIG. 138, Group XVIII.—The Potamogale.

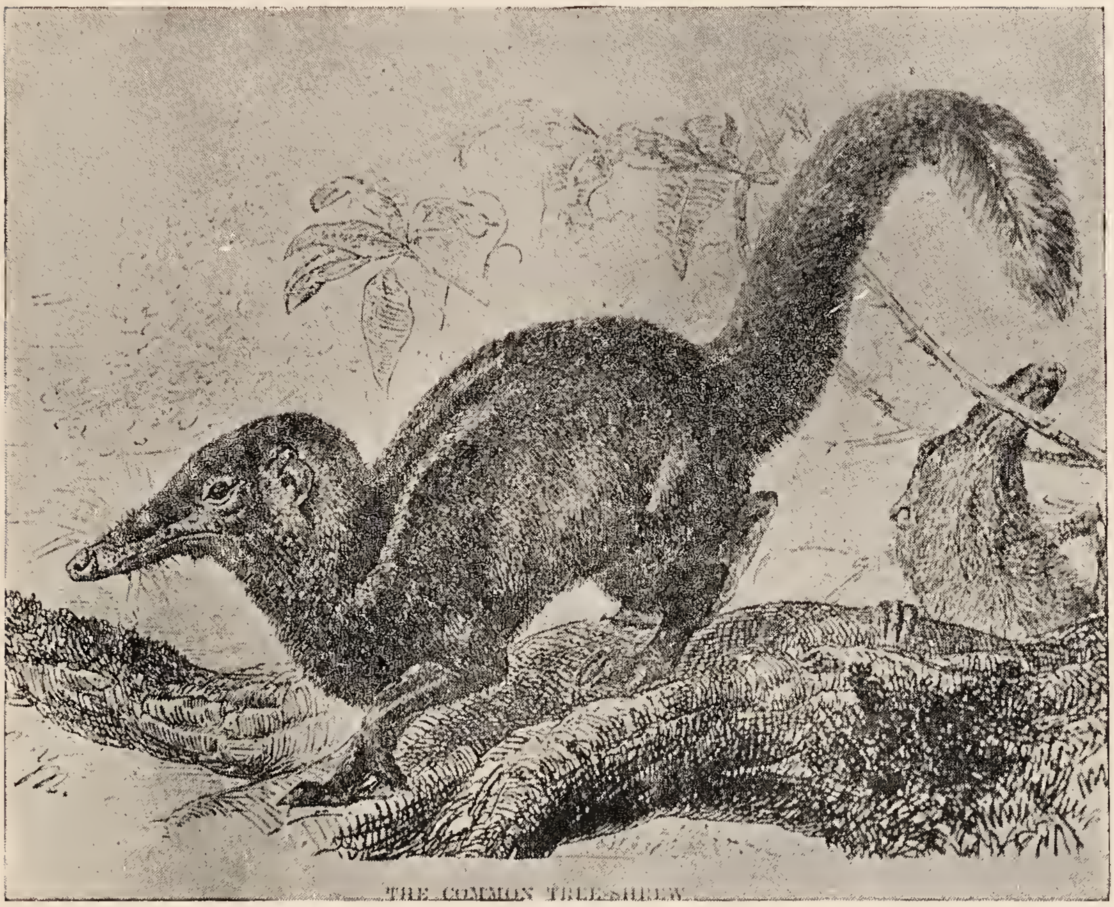

THE COMMON TREE-SHREW

FIG. 139, Group XVIII.—The Common Tree-Shrew.

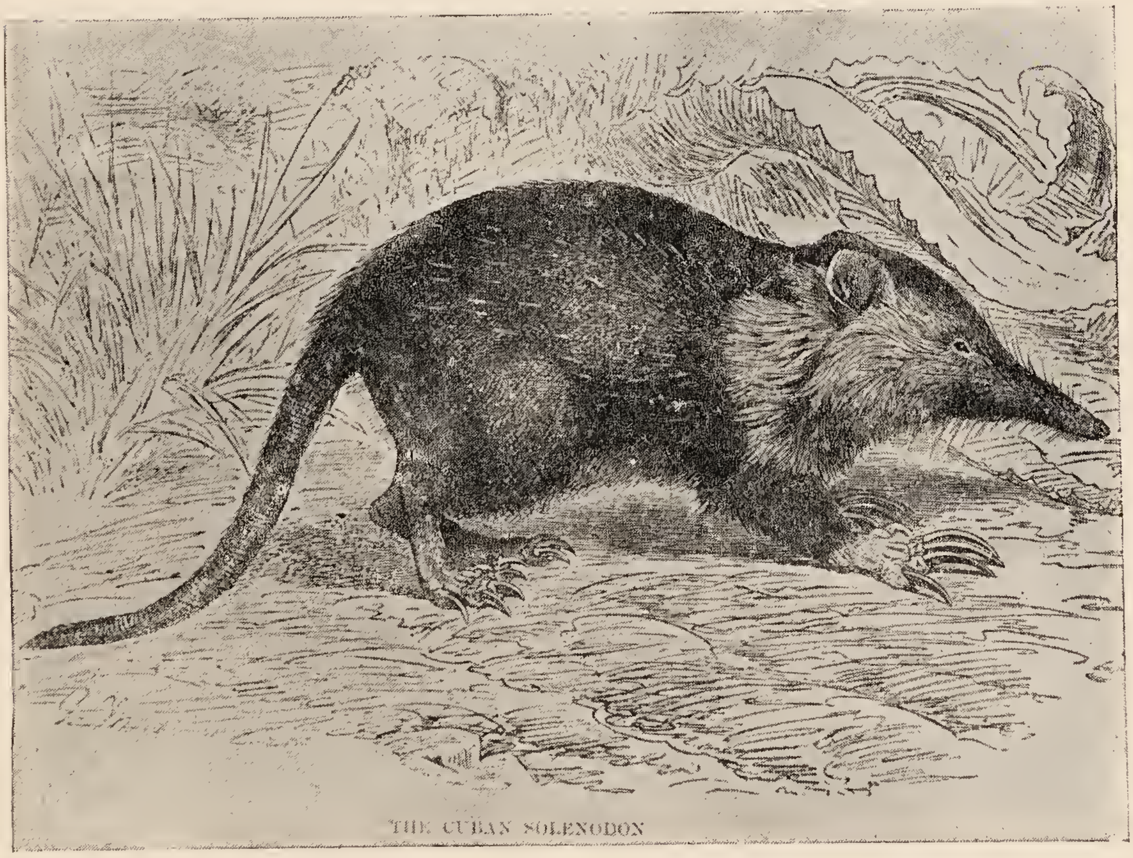

THE CUBAN SOLENODON

FIG. 140, Group XVIII.—The Cuban Solenodon.

GROUP IX.—ACRANIA.

In Fig. 116 we have the adult amphioxus (No. 15), under the term "acrania" (headless), compared with a young lamprey larva (16). The amphioxus is magnified four times. The young lamprey, eleven days after creeping out of the egg, is magnified forty-five times. The same letters indicate the same parts in both figures.

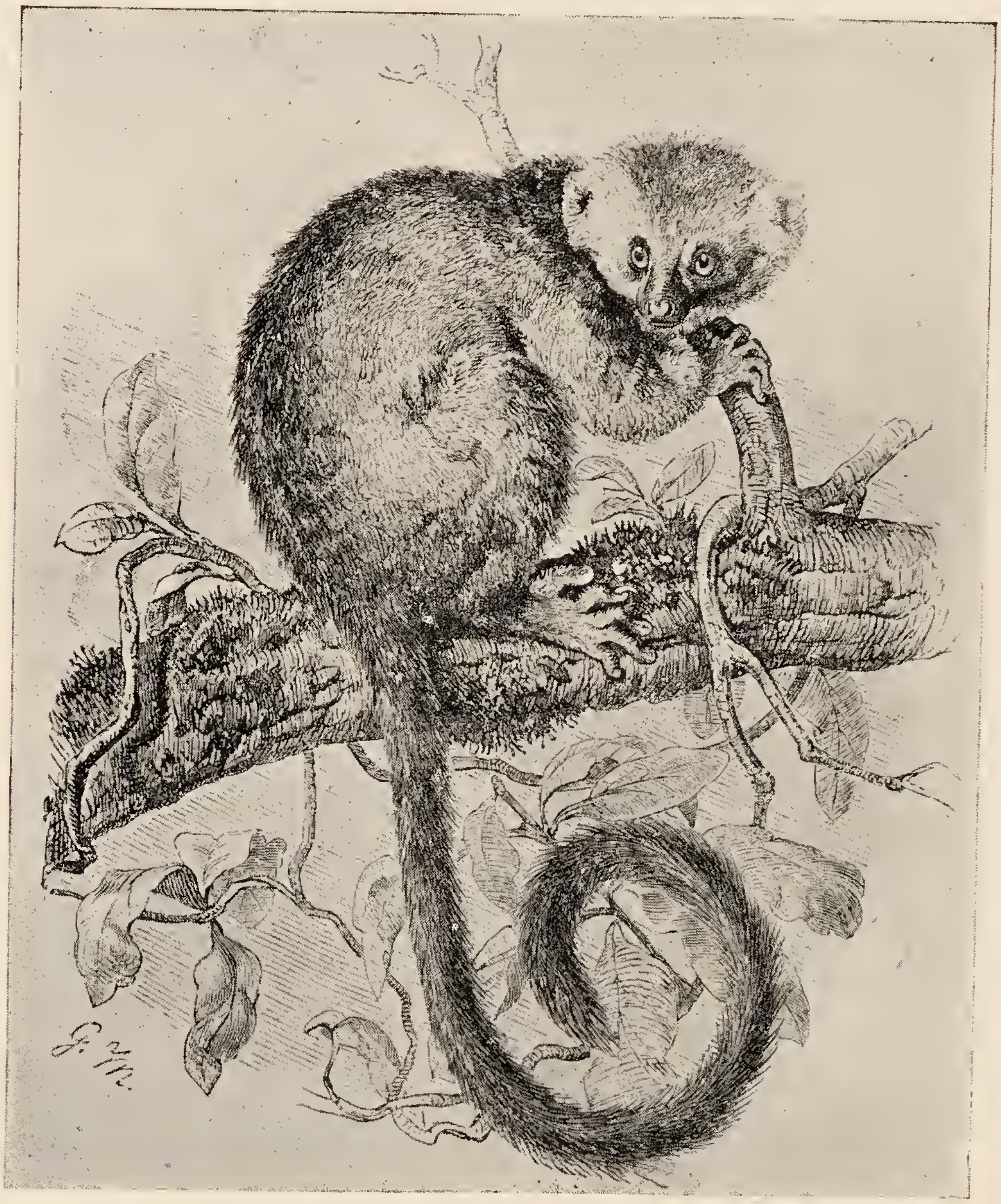


FIG. 141, Group XIX.—The Gentle Lemur.

The chief characteristics which distinguish the vertebrates as a whole from the invertebrates are: "(1) The evolution of the primitive brain into a dorsal medullary tube; (2) the formation of the chorda between the medullary tube and the gut; (3) the division of the gut into branchial (gill) and hepatic (liver) gut; and (4) the internal articulation or metamerism.

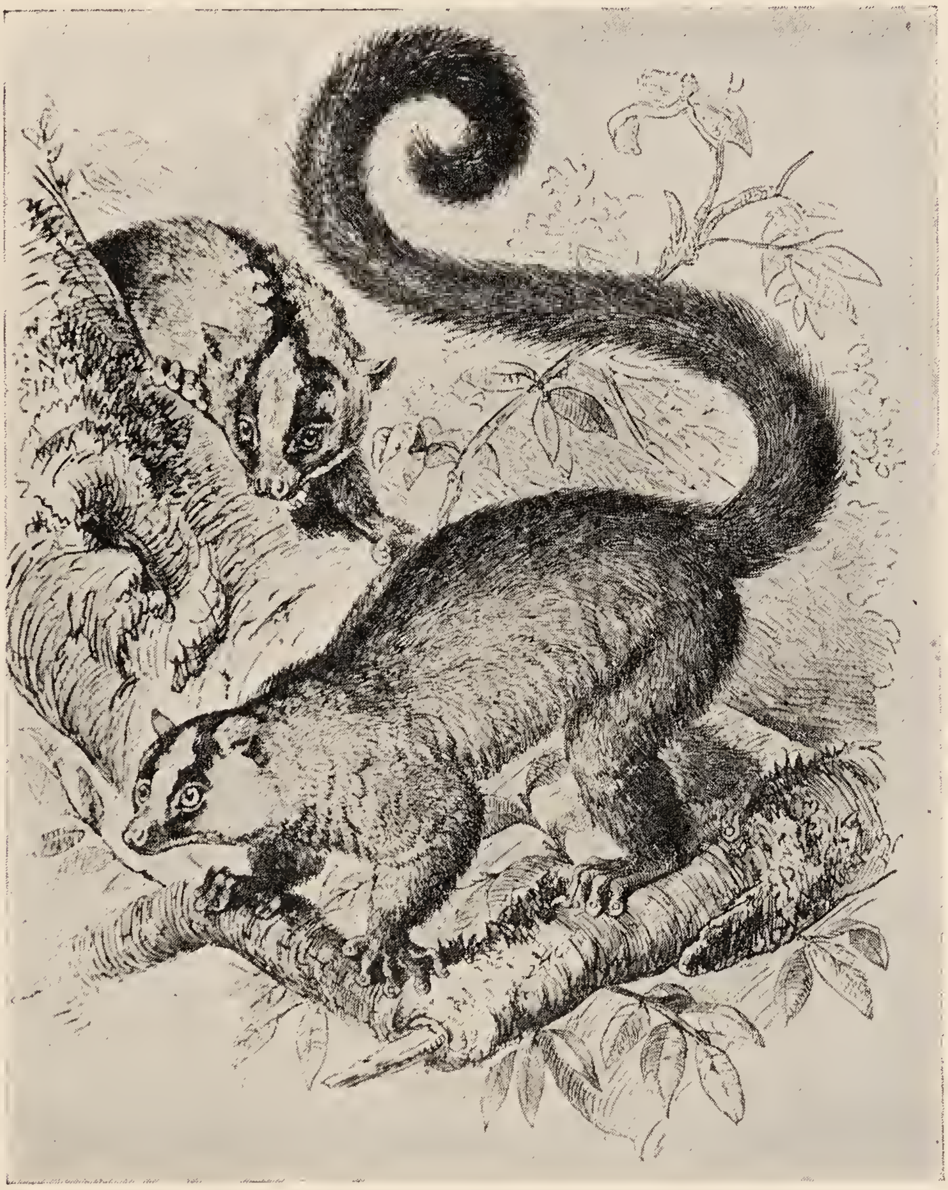


FIG. 142, Group XIX.—The Forked Mouse-Lemur.

"The whole vertebrate stem divides first into the two chief sections of acrania (the skull-less) and craniota (with skulls). The amphioxus is the only surviving representative of the older and lower section, the acrania. All the other vertebrates belong to the second division, the craniota—skull animals.

"The craniota descend directly from the acrania, and these from the primitive chordonia."

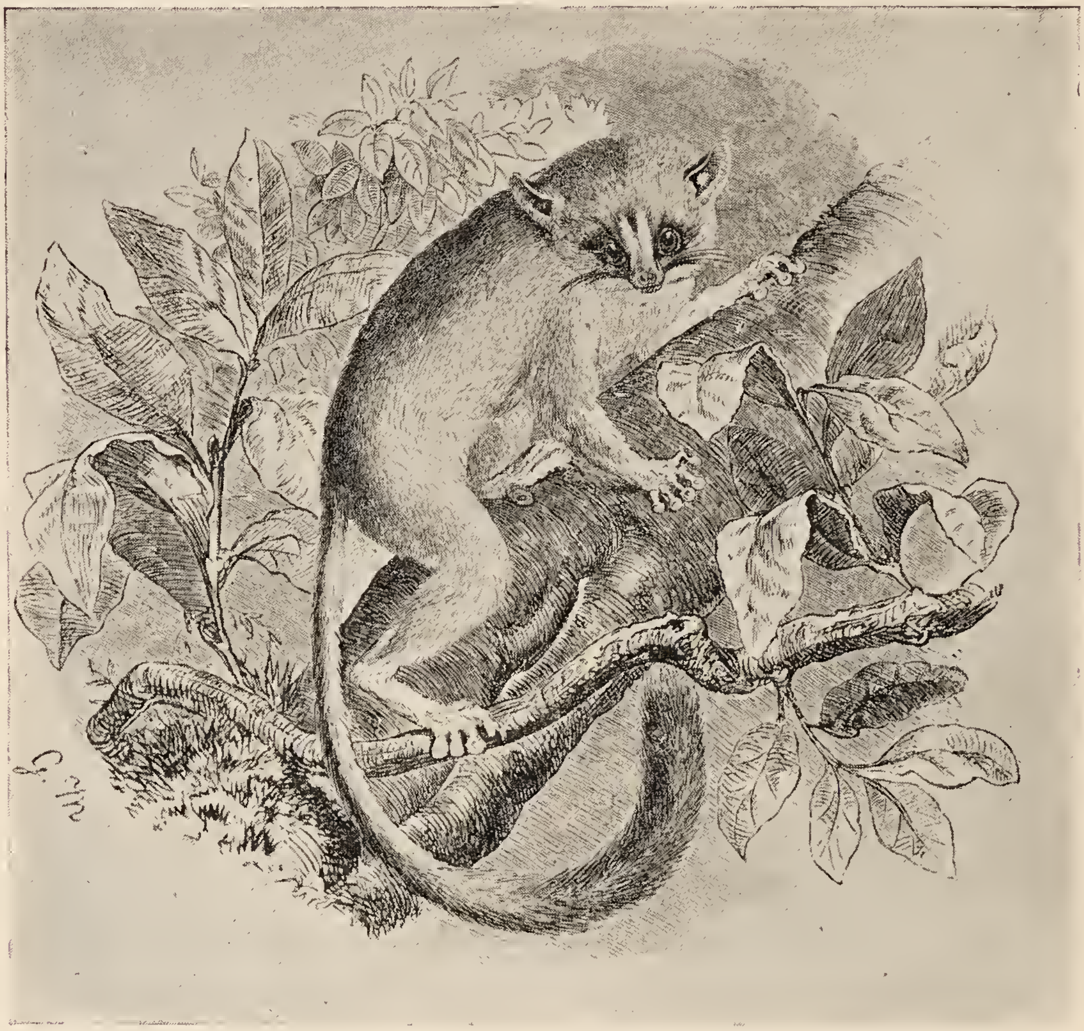


FIG. 143, Group XIX.—Murine Mouse-Lemur.

The amphioxus is the lowest vertebrate, and the ascidian is the nearest related invertebrate.

"The amphioxus is important not merely because it fills the deep gulf between the invertebrates and the vertebrates, but also because it shows us to-day the typical vertebrate in all its simplicity."

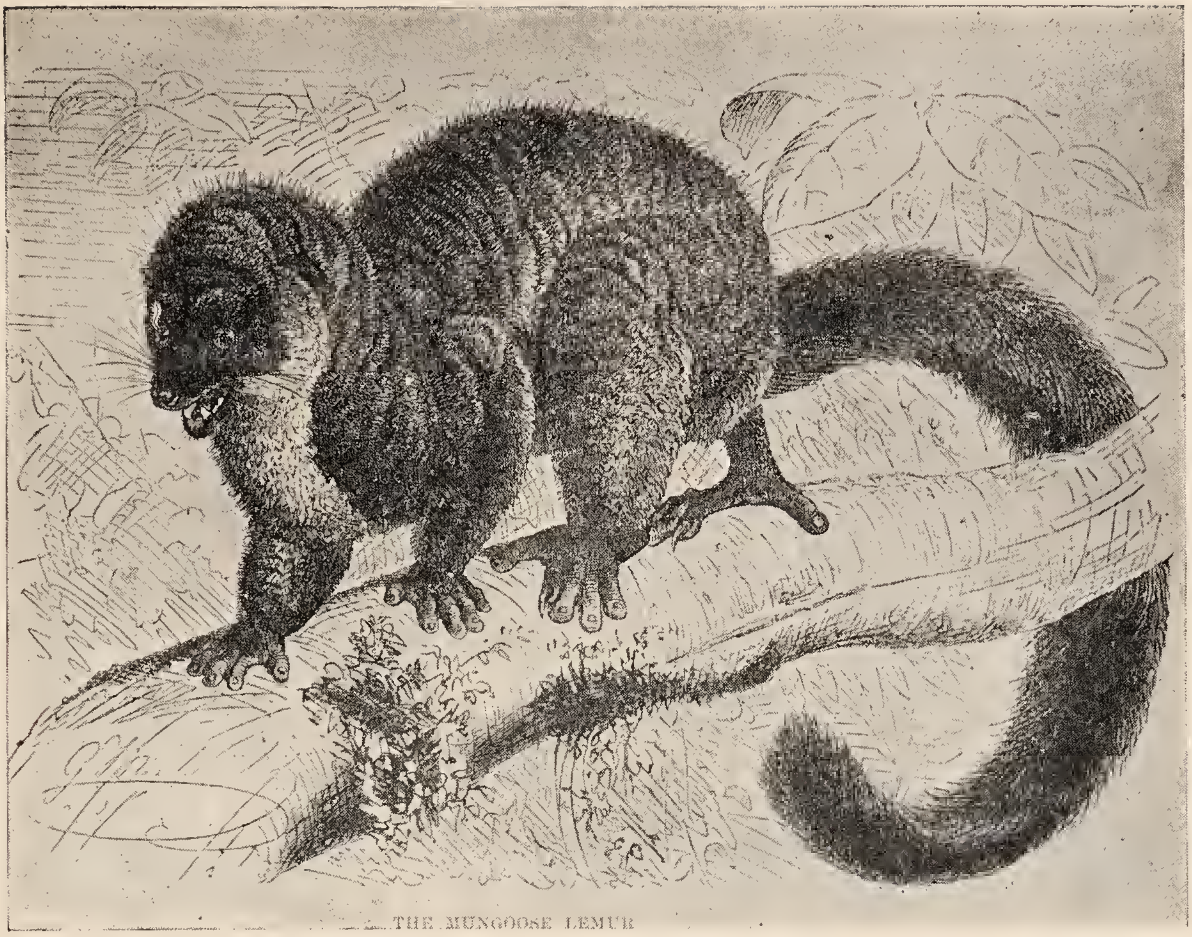

THE MUNGOOSE LEMUR

Fig. 144, Group XIX.—The Mungoose Lemur.

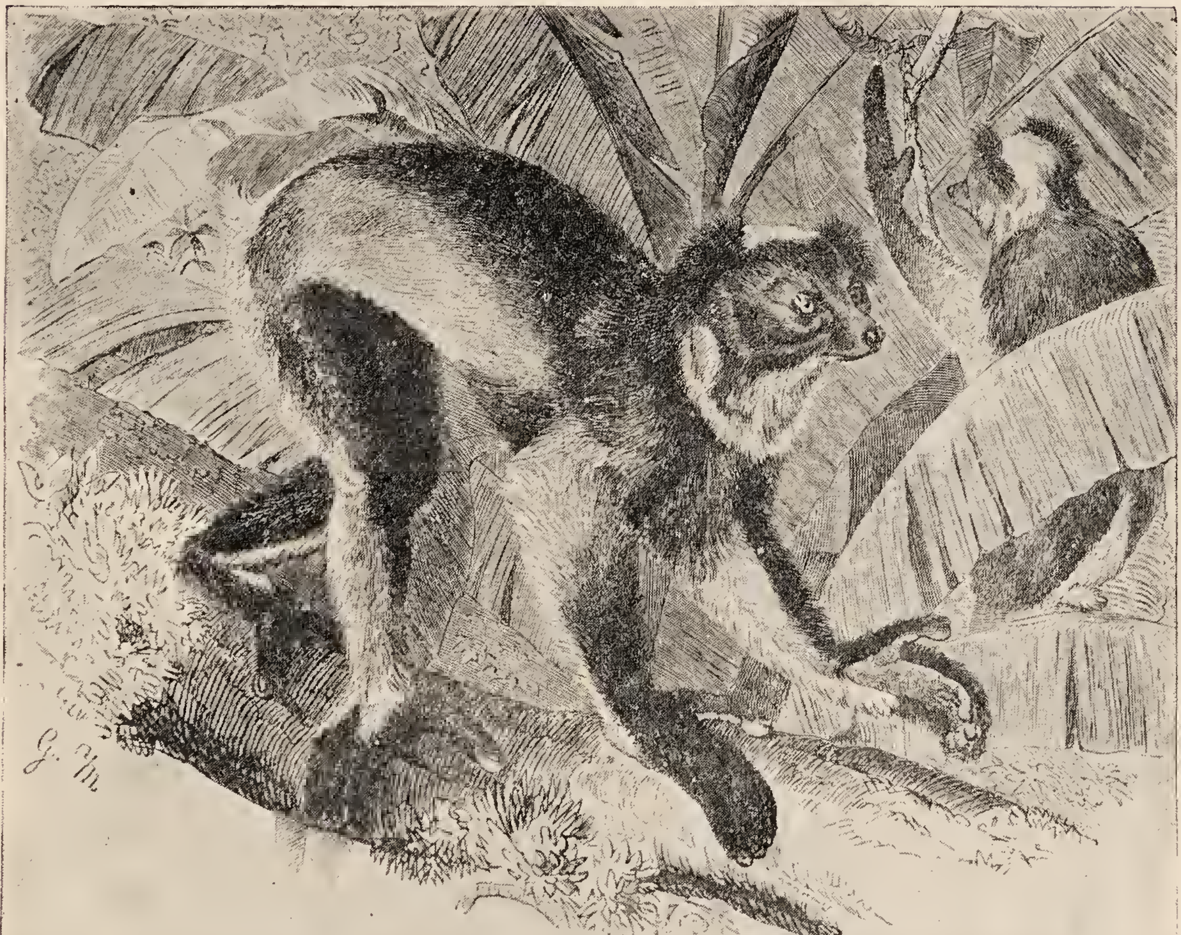


Fig. 145, Group XIX.—The Indri Lemur.

GROUP X.—LAMPREYS.

When we pass from the amphioxus, we find the lampreys a striking connecting link between it and the fishes.

All the skull-animals are divided into cyclostoma (round-mouthed) and gnathostoma (jaw-mouthed). There are only a few of the round-mouthed in existence now.

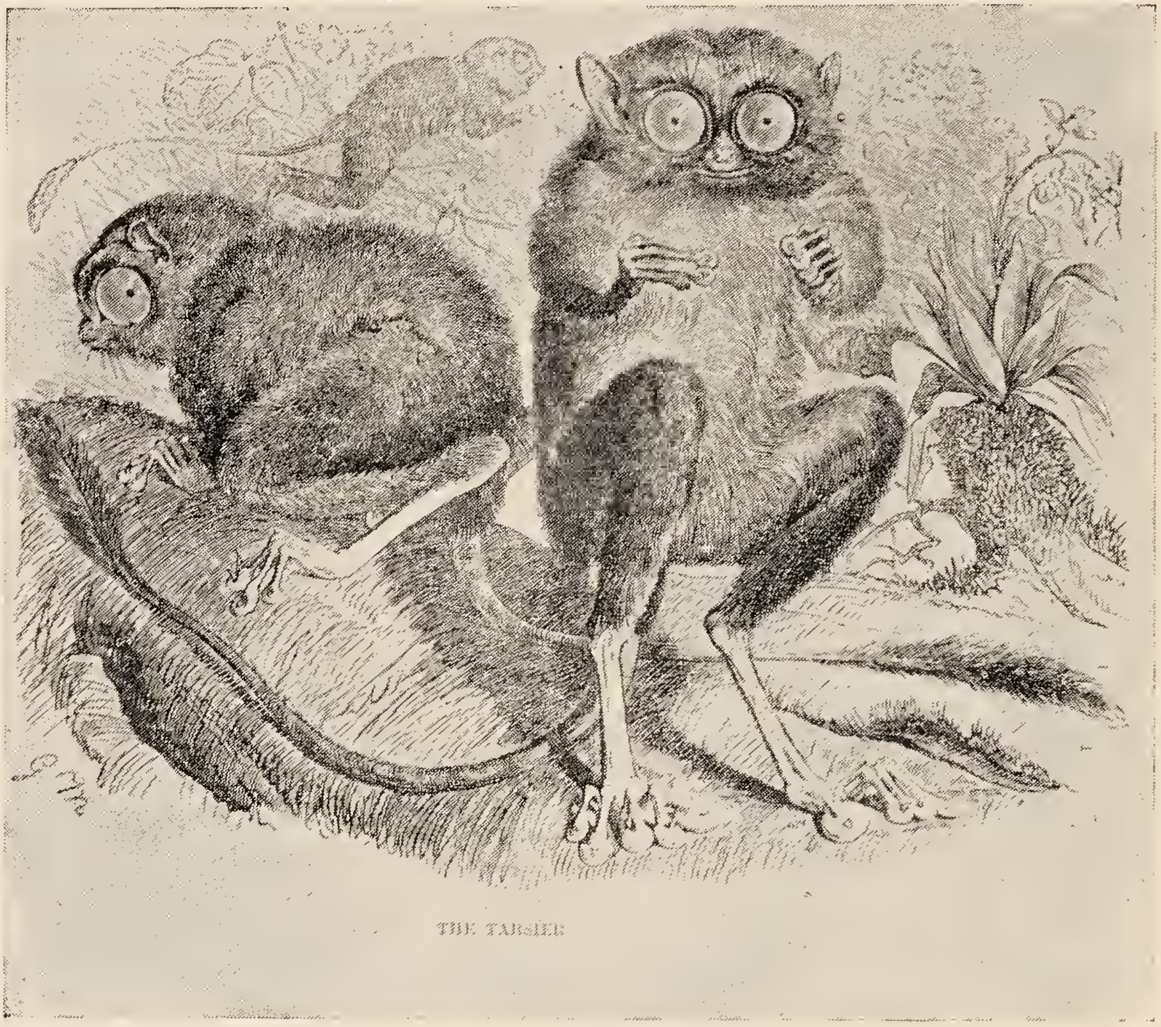


Fig. 146, Group XIX.—The Tarsier.

There is no long skeleton. A very rudimentary skull is developed at the foremost end of the chorda and a membrane encloses the brain, which is merely a small swelling of the spinal marrow, a simple vesicle at first. It afterwards divides into five cerebral vesicles, as does the brain of all the vertebrates above this class.

GROUP XI.—SHARKS (Fig. 118).

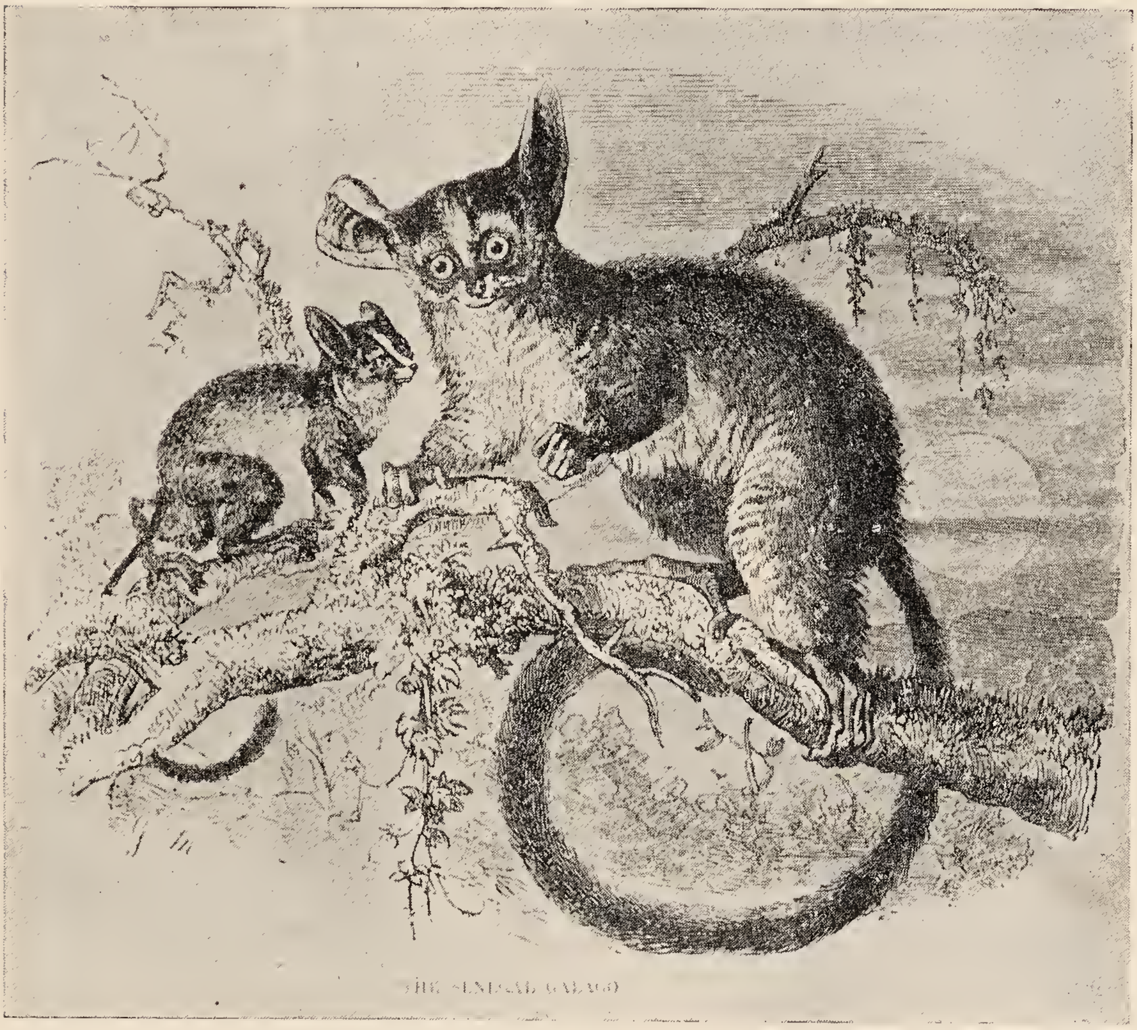


Fig. 147, Group XIX.—The Senegal Galago.

GROUP XII.—CROSSOPTERYGIAN FISHES, OR FOSSIL GANOIDS.

From the primitive fishes (selachii) were developed the ganoids (plated fishes), abundant as fossils. Some of these ganoids are like sharks, others approach the dipneusts. (See p. 123, Part I.)

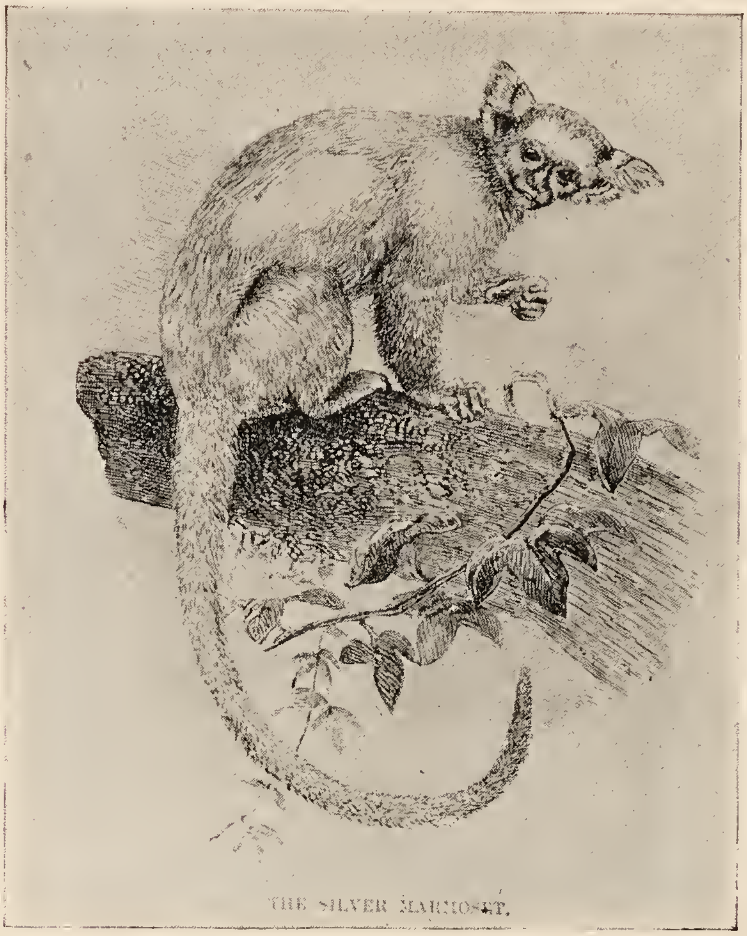

THE SILVER MARMOSET.

Fig. 148, Group XX.—The Silver Marmoset.

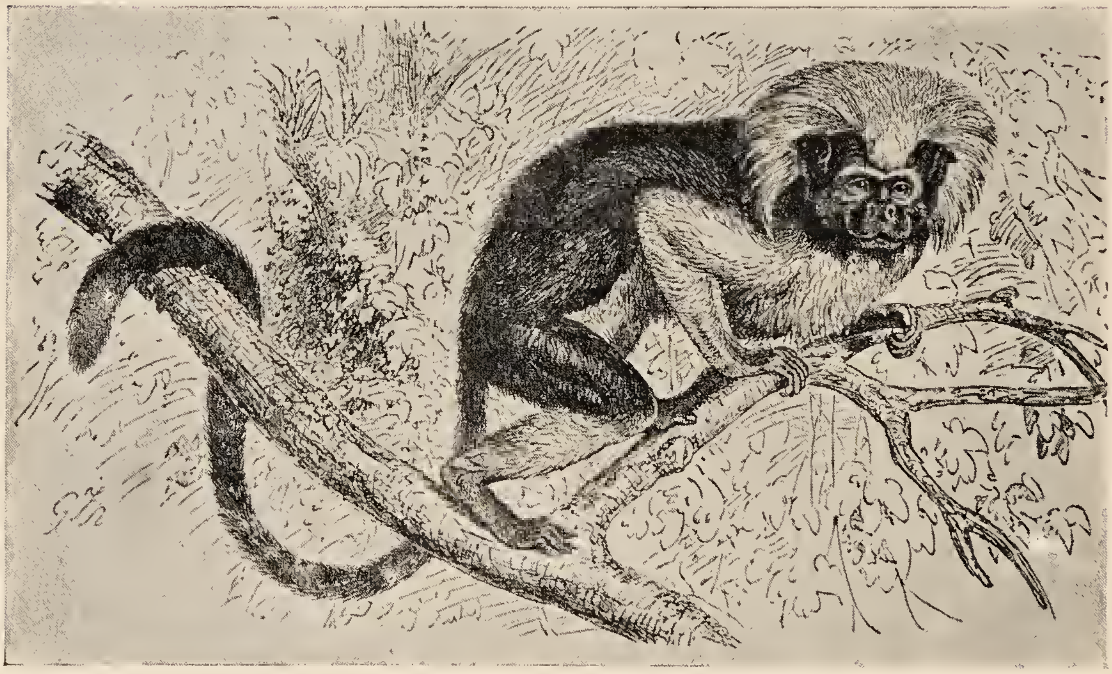


Fig. 149, Group XX.—The Pinche.

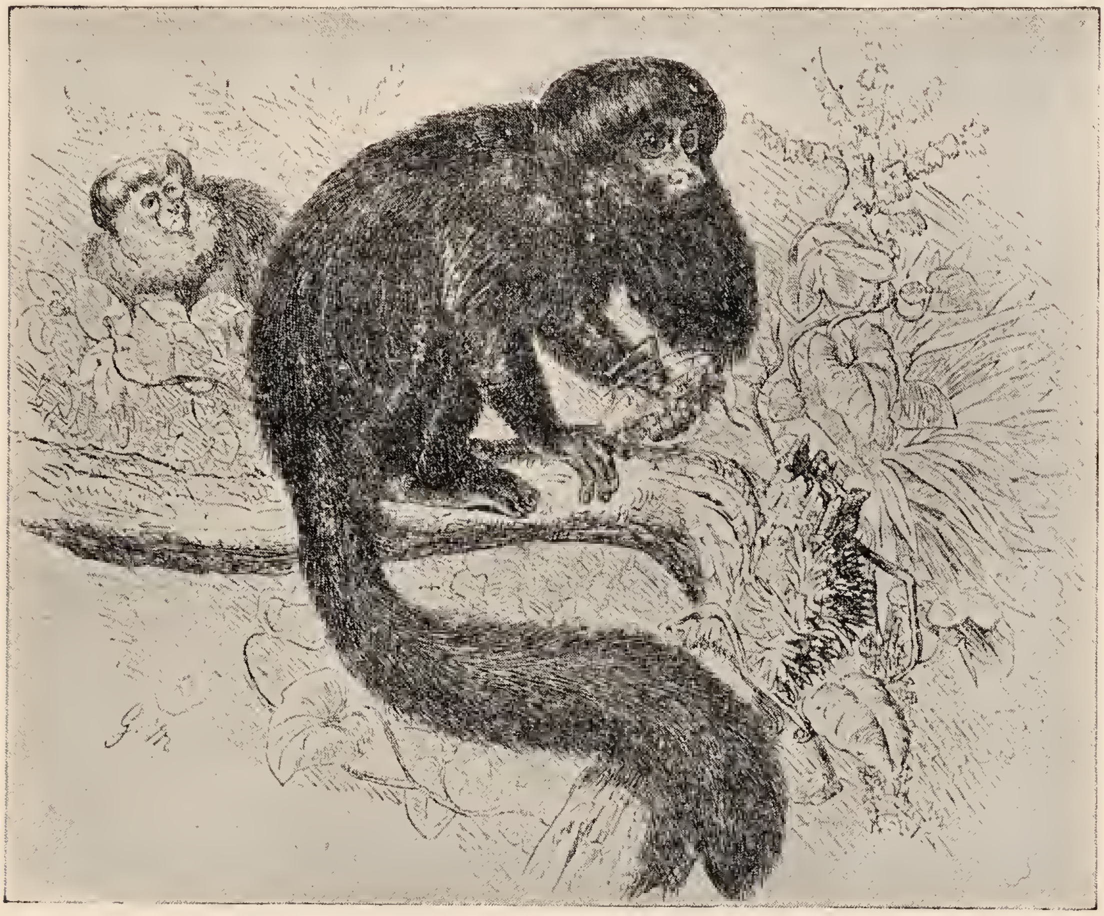


FIG. 150, Group XX.—The Black Saki.

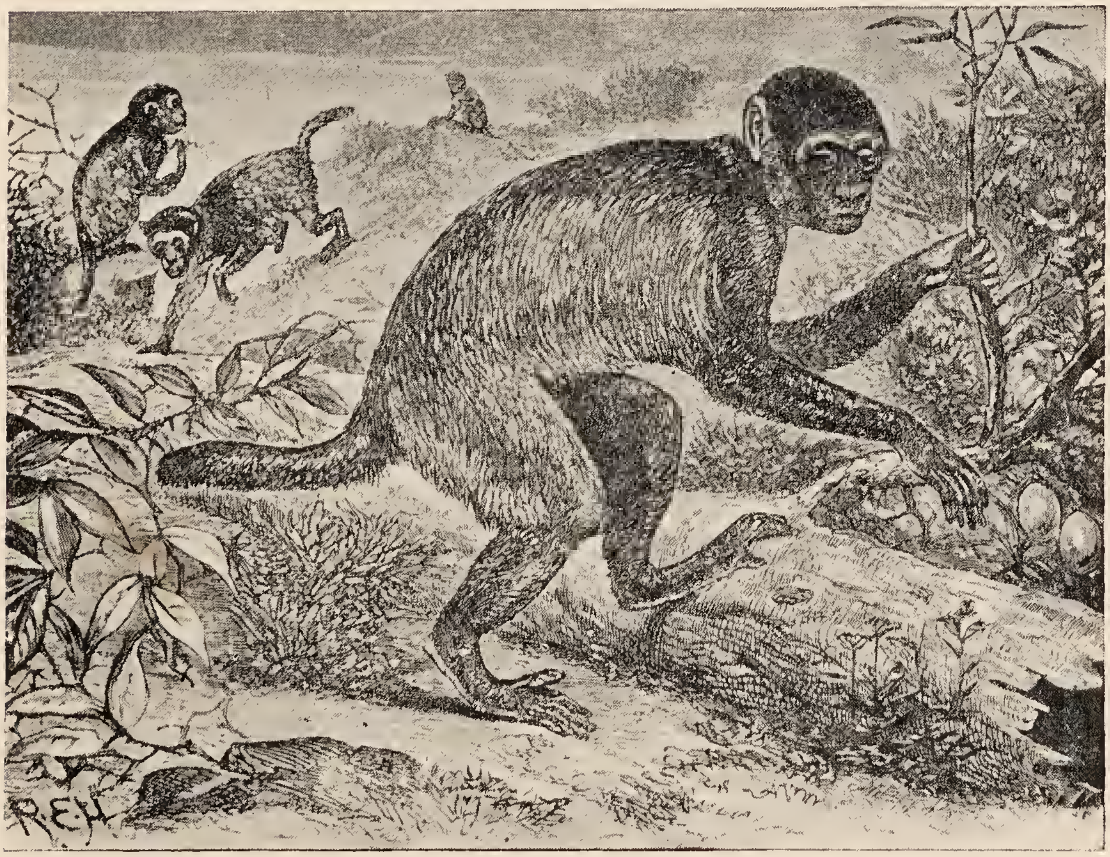


FIG. 151, Group XX.—The Black-headed Uakari.

GROUP XIII.—DIPNEUST (DOUBLE-BREATHING) FISH.

GROUP XIV.—AMPHIBIANS.

Amphibians are the first land animals. The group which concerns us is the roof-headed (stegocephali), for from these the reptiles came.

GROUP XV.—REPTILES.

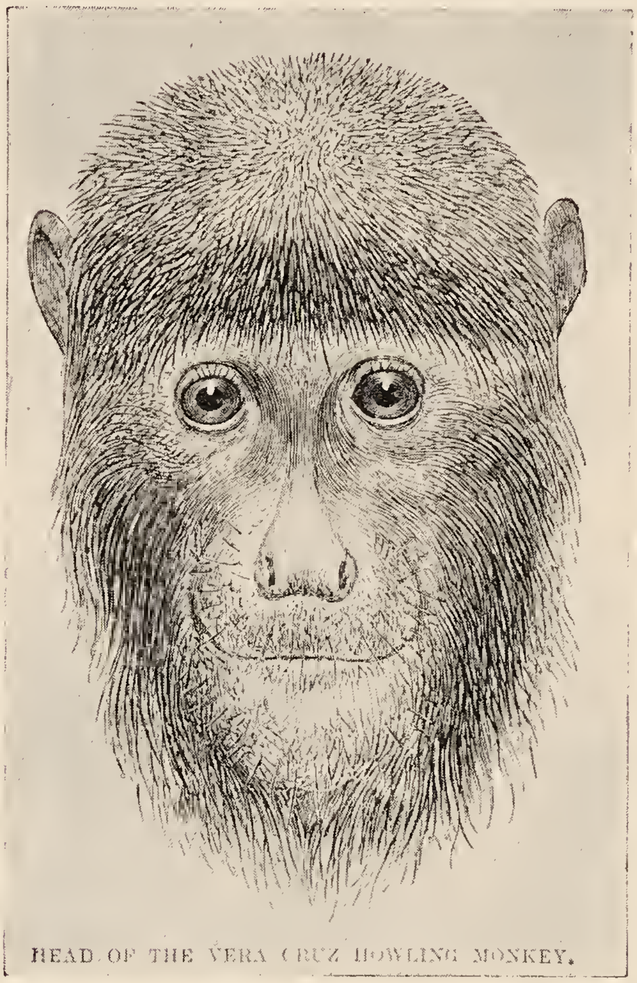

HEAD OF THE VERA CRUZ HOWLING MONKEY.

Fig. 152, Group XX.—The Vera Cruz Howling Monkey.

GROUP XVI.—PRO-MAMMALS.

Group XVI. are defective mammals; the monotremes.

GROUP XVII.—THE MARSUPIALS, OR POUCHED ANIMALS.

All mammals appear to have come through

marsupial ancestors. Marsupials are very ancient and very widely distributed. A few examples are given (Figs. 129 to 135), and these should be carefully studied and their great variety noted.

GROUP XVIII.—INSECT-FEEDERS (INSECTIVORS).

In this pedigree I have accepted the view that man and the higher living groups came through the insect-eating group. (See Part I., pp. 151–155, for important explanations.) Further specimens of this most interesting group are given in Figs. 136–139.

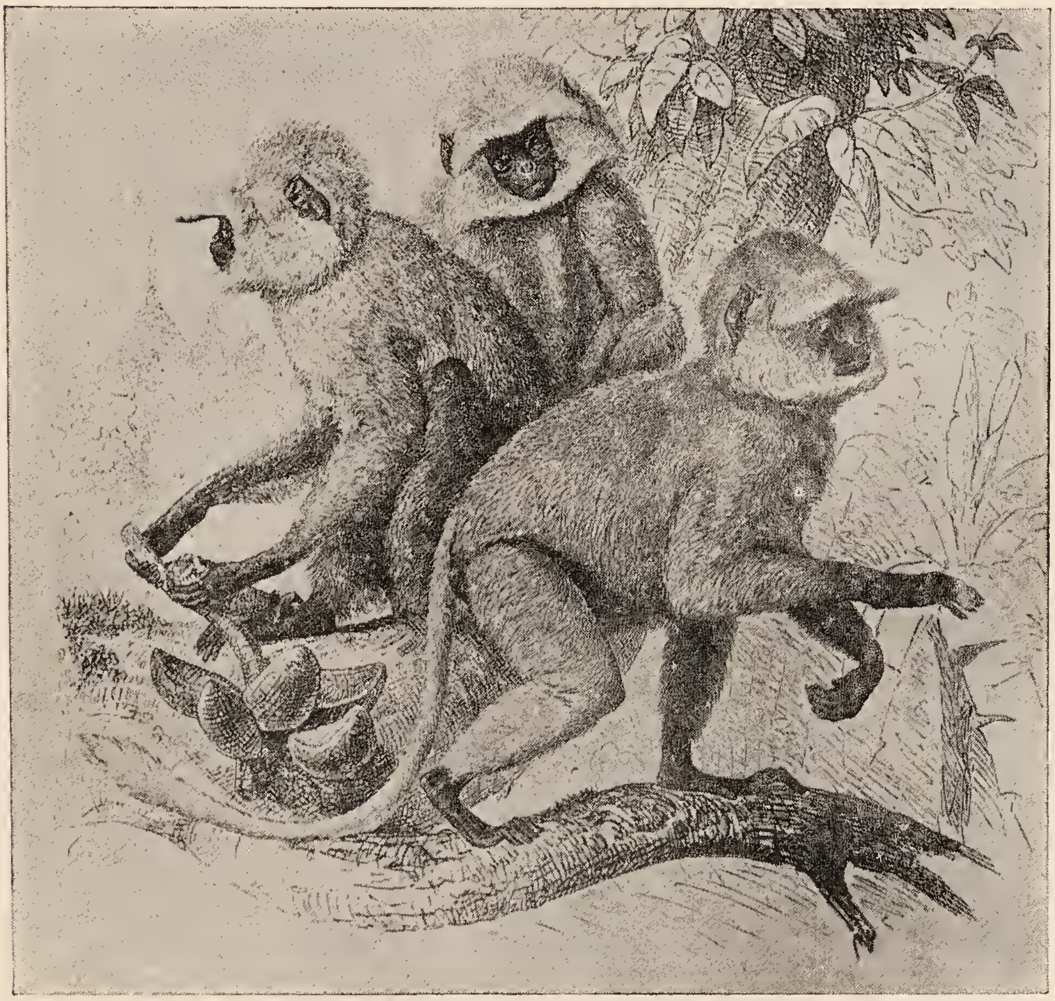


FIG. 153, Group XXI.—Hanumán, true Langur.

GROUP XIX.—LEMURS.

Figs. 141–147. (See also Part I., pp. 155–161.)

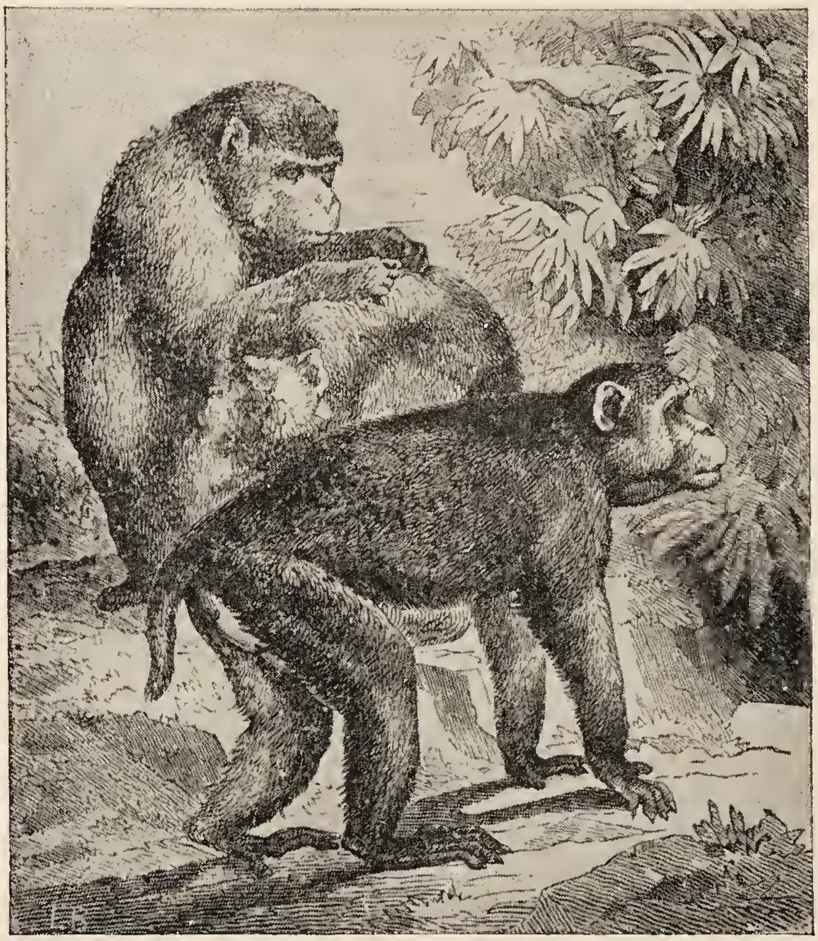


FIG. 154, Group XXI.—Bengal Monkey.

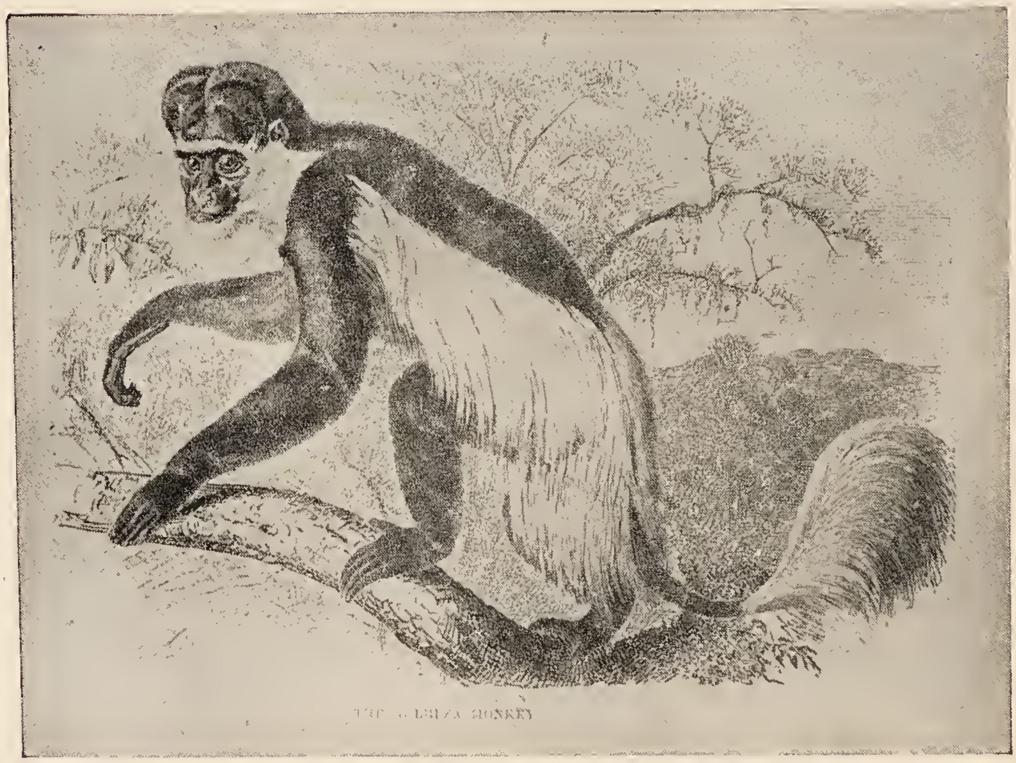

THE GUEREZA MONKEY

FIG. 155, Group XXI.—The Guereza Monkey.

GROUP XX.—PLATYRRHINE MONKEYS.

The flat-nosed monkeys are found only in America (Figs. 148–152). (See also Part I., pp. 162–167.)

N.B.—This group is not in the direct line of man's pedigree.

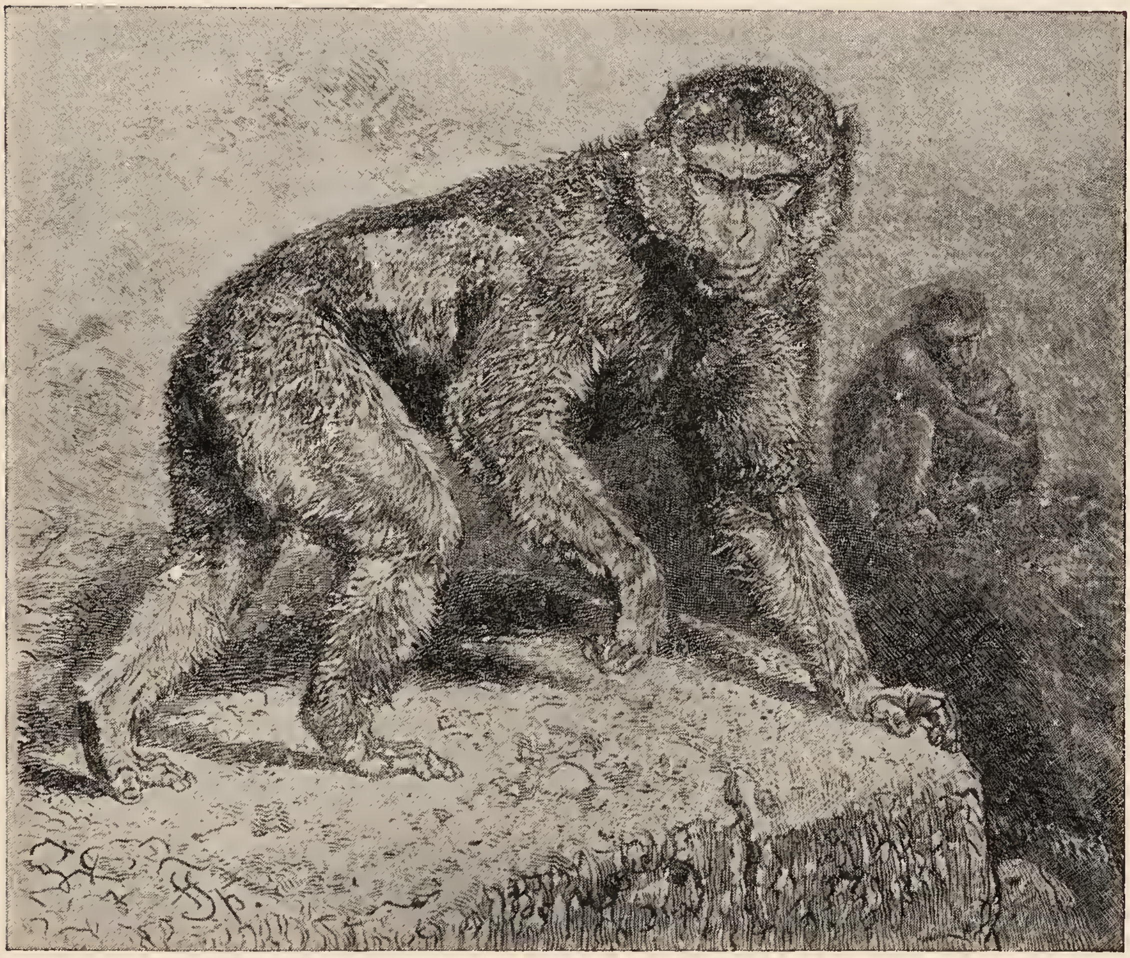


FIG. 156, Group XXI.—Margot, or Barbary Macaque.

GROUP XXI.—CATARRHINE MONKEYS.

The down-nosed monkeys are found in the Old World (Figs. 153–165). These are the blood-relatives of man, and therefore of enormous interest. The difference between the lowest and the highest in this group is greater than the difference between the highest ape and the lowest man.

We require photographs of thousands of monkeys and apes to enable us to grasp the amazing variety of their forms. And perhaps nothing would so clearly bring home to us the fact of our family relationship. (For other specimens and for low races of men see pp. 168–184, and Fig. 182, Part I.)

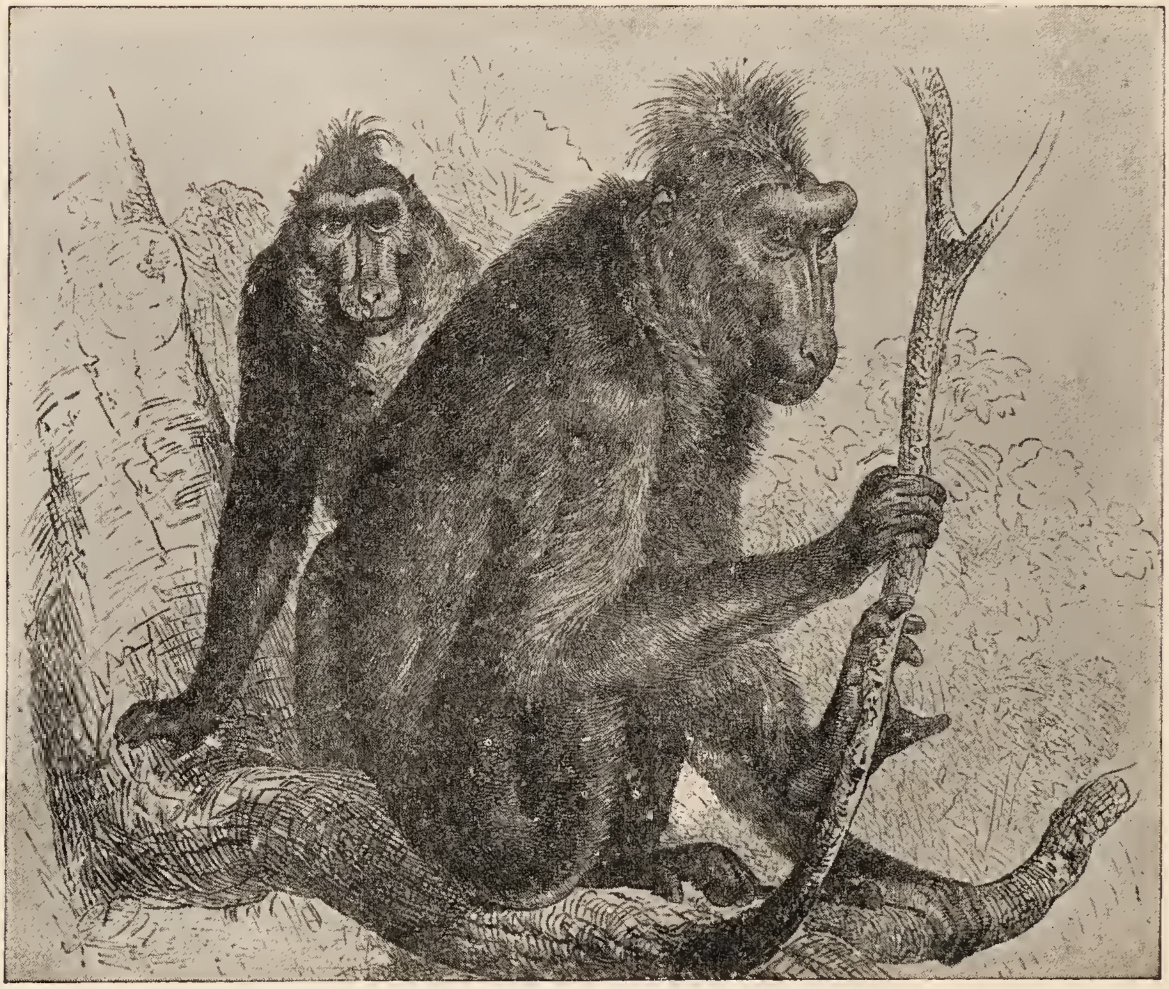


FIG. 157, Group XXI.—Black Ape.

Those who have carefully followed the groups by which I have attempted to show the chief stages in the evolution of man will have little difficulty in understanding the tree of life. This tree is slightly adapted from Professor Haeckel's. In seeking the pedigree of man, it is only necessary to follow the names on the *trunk* of the tree.

A few branches are given to show how various animals went off on side-lines, but to show all such would require a tree with several thousands of branches.

Perhaps it is hardly necessary to say that no such tree can do more than set forth *in a general way* the great discoveries of science. It is not fair, therefore, to look for mathematical accuracy or scientific finality in this tree.

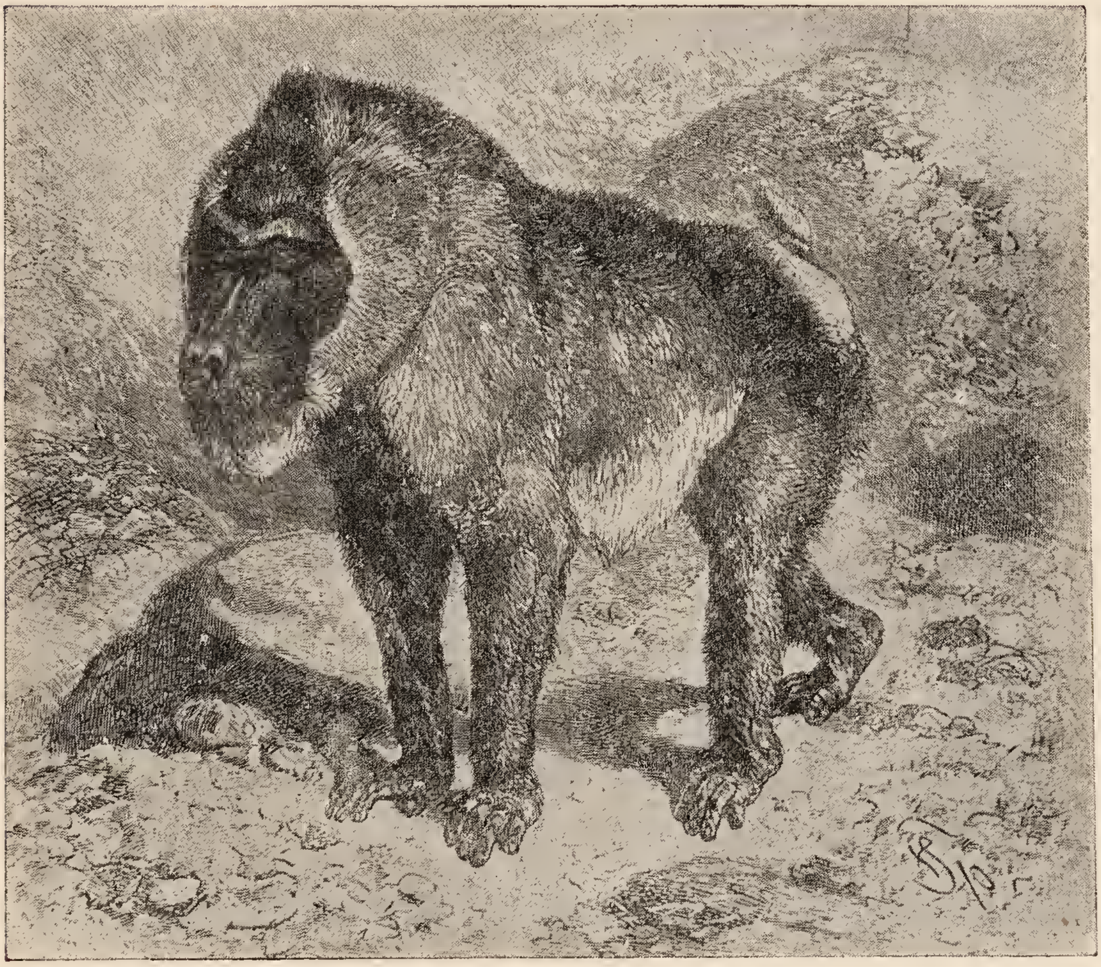


FIG. 158, Group XXI.—The Drill.

The following account of a battle is not only interesting, but helps to bring out points of contact between the conduct of monkeys and men.

The Hanumán, or true Langur (Fig. 153), Semnopithecus Entellus, is found in the Northern part of Peninsular India. The natives protect them, and they are remarkably numerous and tame. They sometimes engage in fierce battles with each other. Mr. T. H. Hughes says that "in April, 1882, when encamped at the village of Singpur, my attention was attracted by a restless gathering of Hanumáns in the grove. Wishing to form some idea as to its cause, I strolled to where the excitement was greatest, and found two opposing troops engaged in demonstrations of an unfriendly character. Two males of one troop, fair-sized brutes, and one of

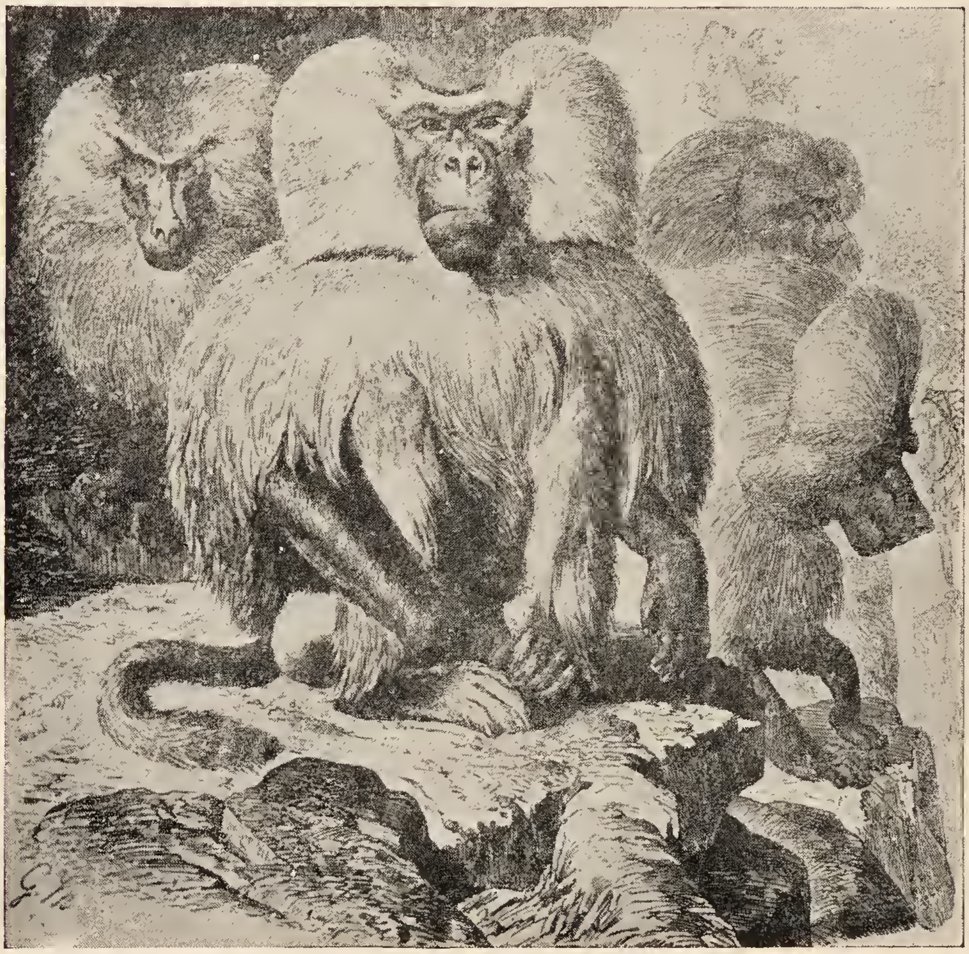


FIG. 159, Group XXI.—Sacred Baboon.

another, a splendid-looking fellow of stalwart proportions, were walking round and displaying their teeth. The solitary gladiator headed a much smaller following than that captained by the other two; and, strange to say, instead of the whole number of monkeys joining in a general *mêlée,* the fortune of the question that had to be decided appeared to have been entrusted to the representative champions. It was some time, at least a quarter-of-an-hour, before actual hostilities took place, when, having got within striking distance, the two monkeys made a rush at their adversary.

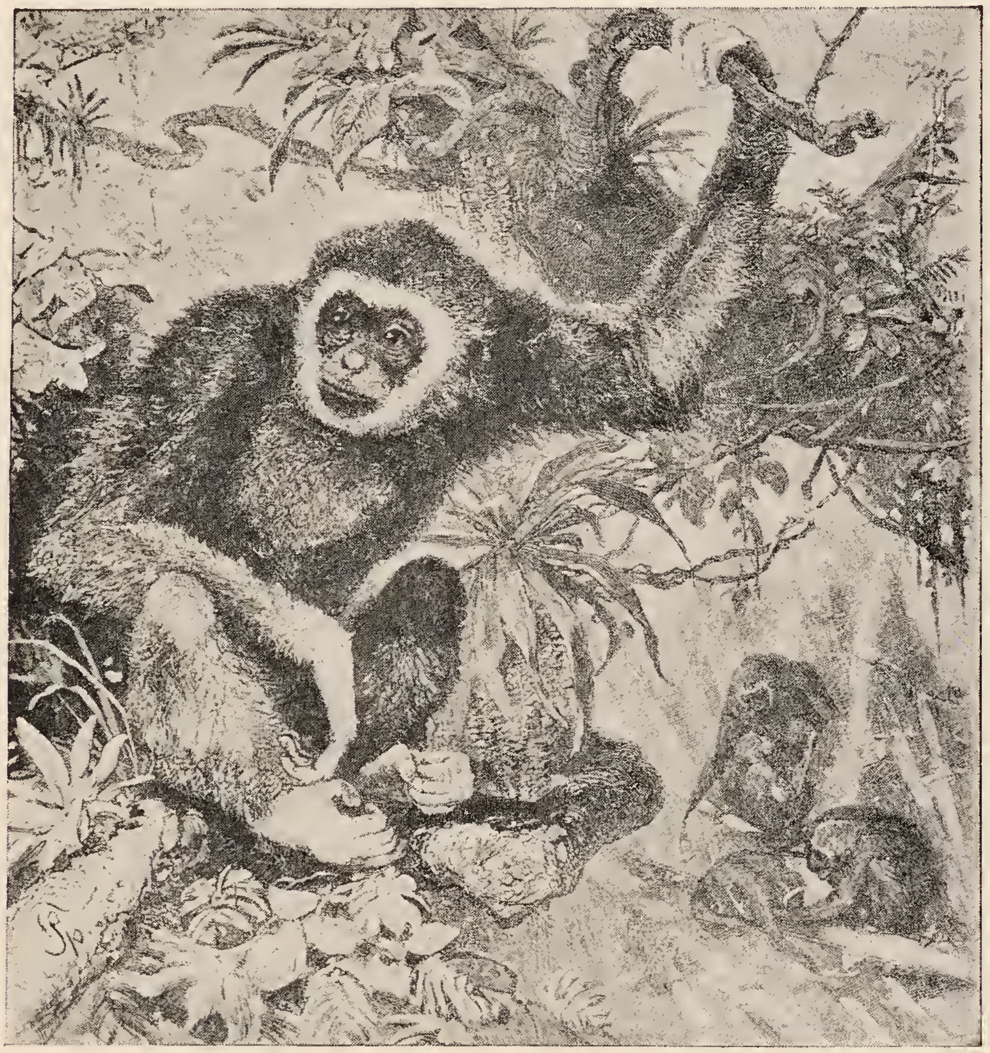


FIG. 160, Group XXI.—White-handed Gibbon.

I saw their arms and teeth going viciously, and then the throat of one of the aggressors was ripped right open, and he lay dying. He had done some damage, however, before going under, having wounded his opponent in the shoulder; and matters then seemed pretty equally balanced between the

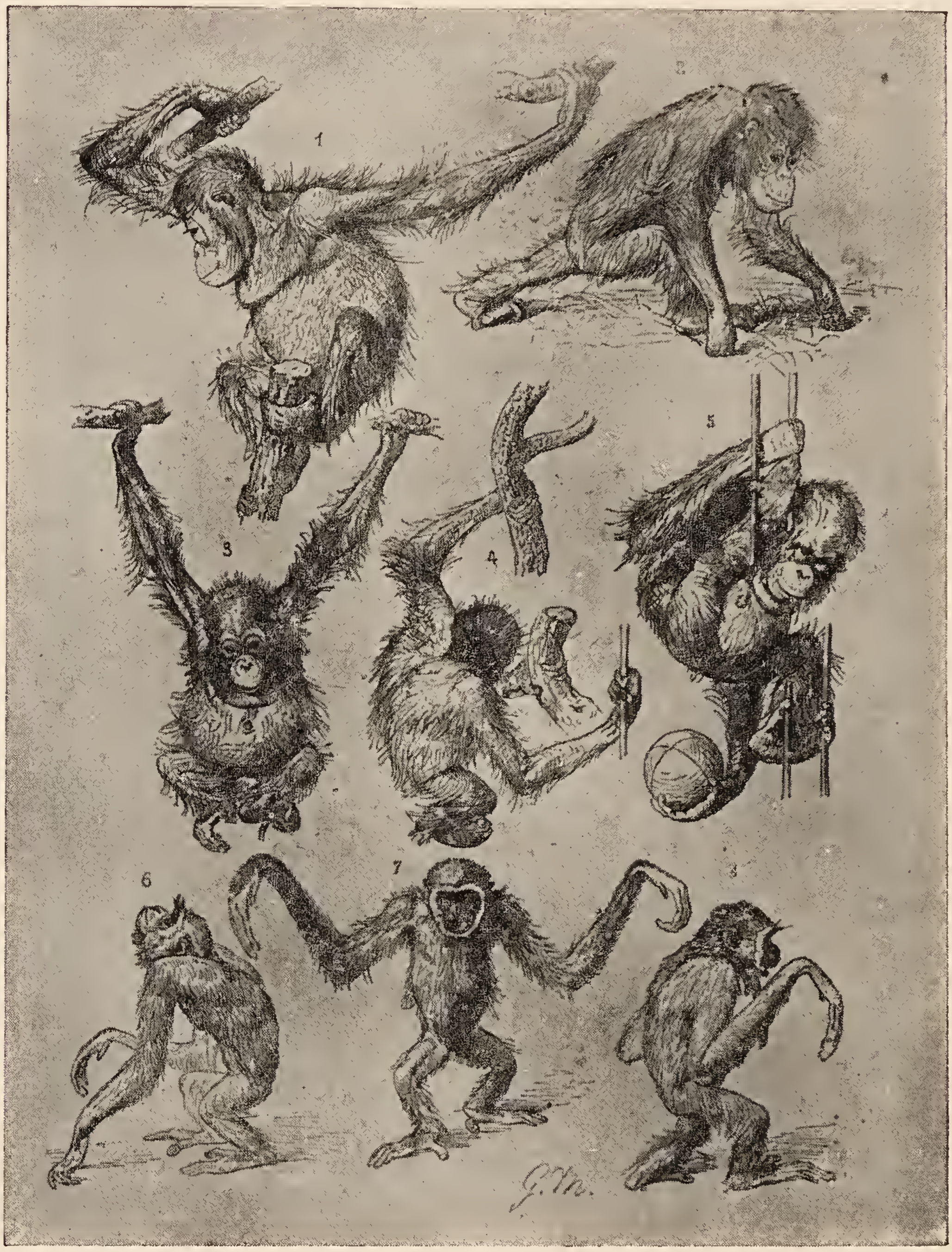


FIG. 161, Group XXI.—Orangs and Gibbons.

remaining strugglers. I confess that my sympathies were with the one champion who had gallantly withstood the charge of his enemies; and I fancy the tide ot victory would have been in his favour had the odds against him not been reinforced by the advance of two females. I felt that the

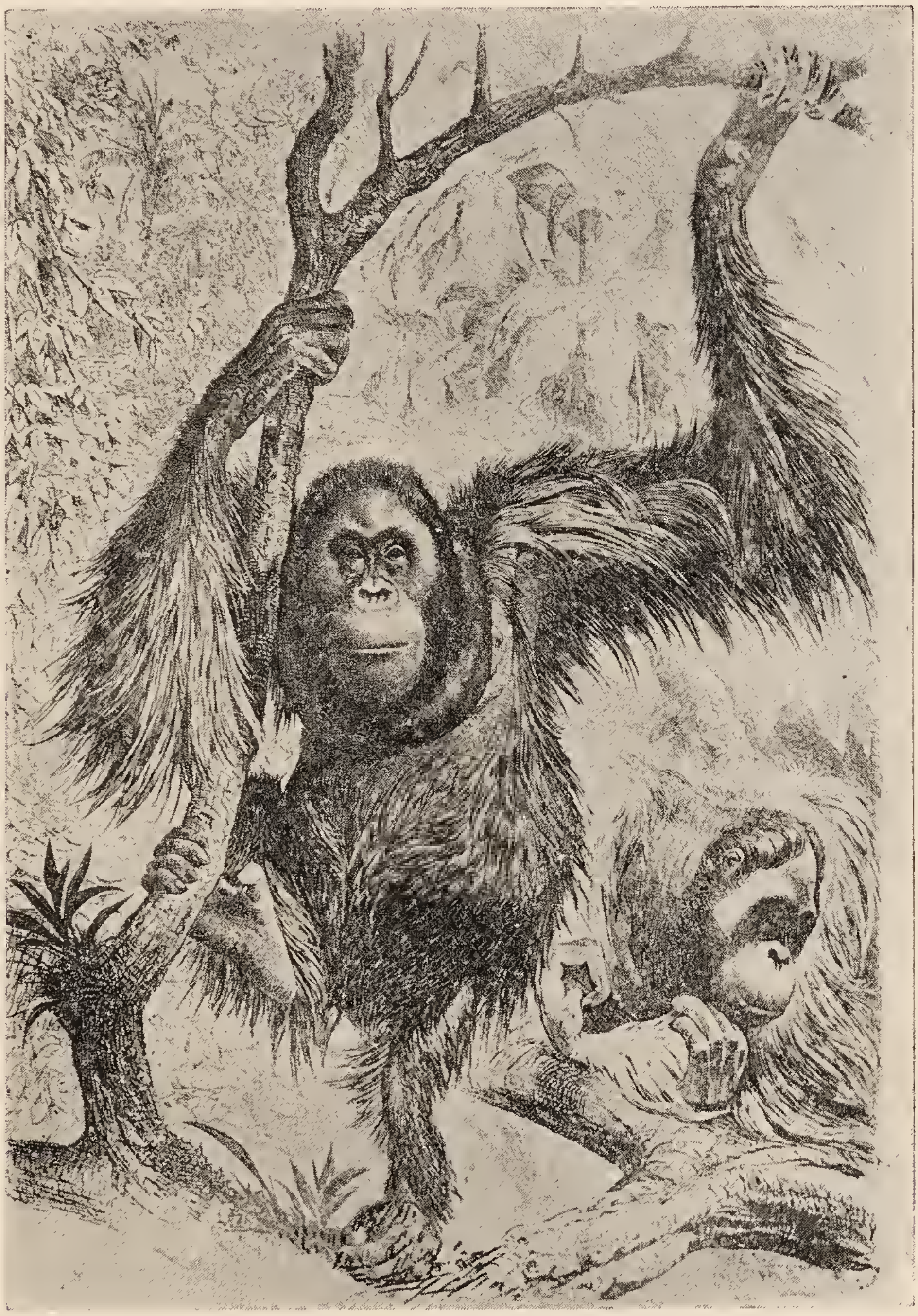


FIG. 162, Group XXI.—Orang.

fight was not a fair one, but was deterred from interfering by a wish to see what the end of the fray would be; and the end, so far as the solitary Hanumán was concerned, soon came. Each female flung herself upon him, and, though he fought his enemies gallantly, one of the females succeeded in seizing

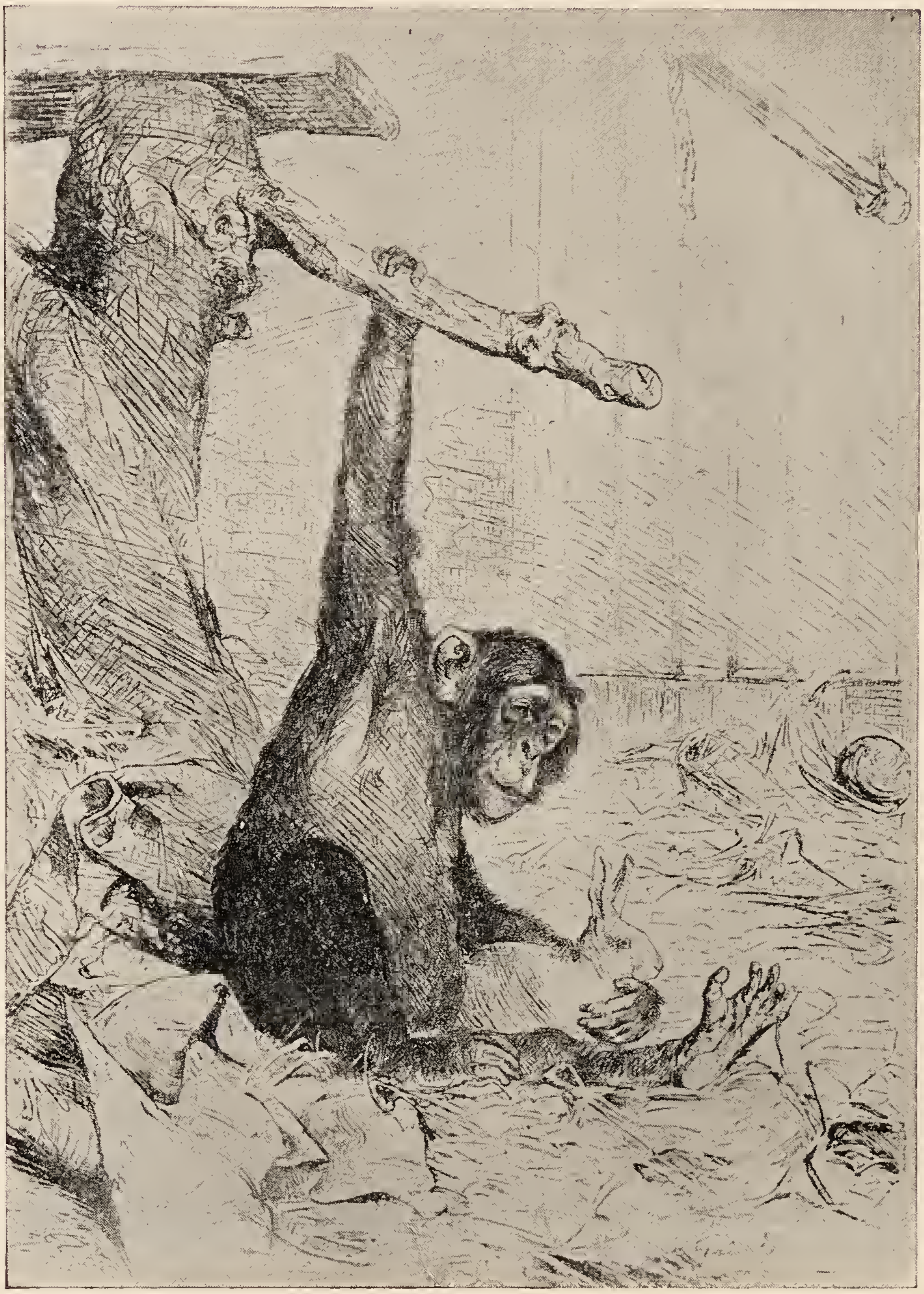


Fig. 163, Group XXI.—Chimpanzee.

him. Possibly he would have been killed outright had I not been present; but, when I saw him so helpless, I interfered on the chance of being able to save him. He was, however, hopelessly mutilated, and before the morning he was dead. Not one of his own troop came to his aid.

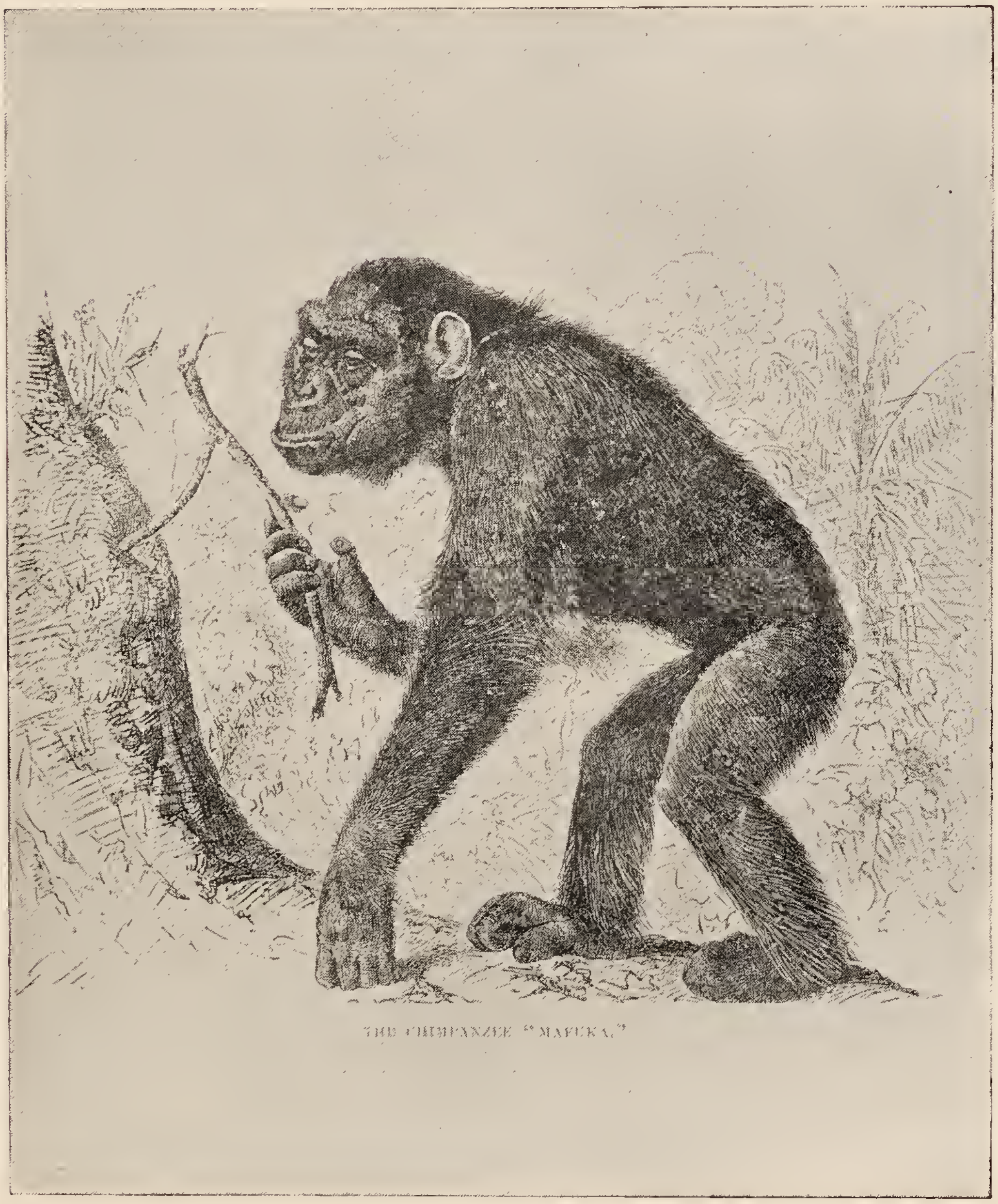

THE CHIMPANZEE "MAFUKA."

FIG. 164, Group XXI.—Chimpanzee (" Mafuka ").

" Had they assisted, they might have fared better, for the result of the defeat was that the whole of the aggressors entered upon a guerilla warfare,

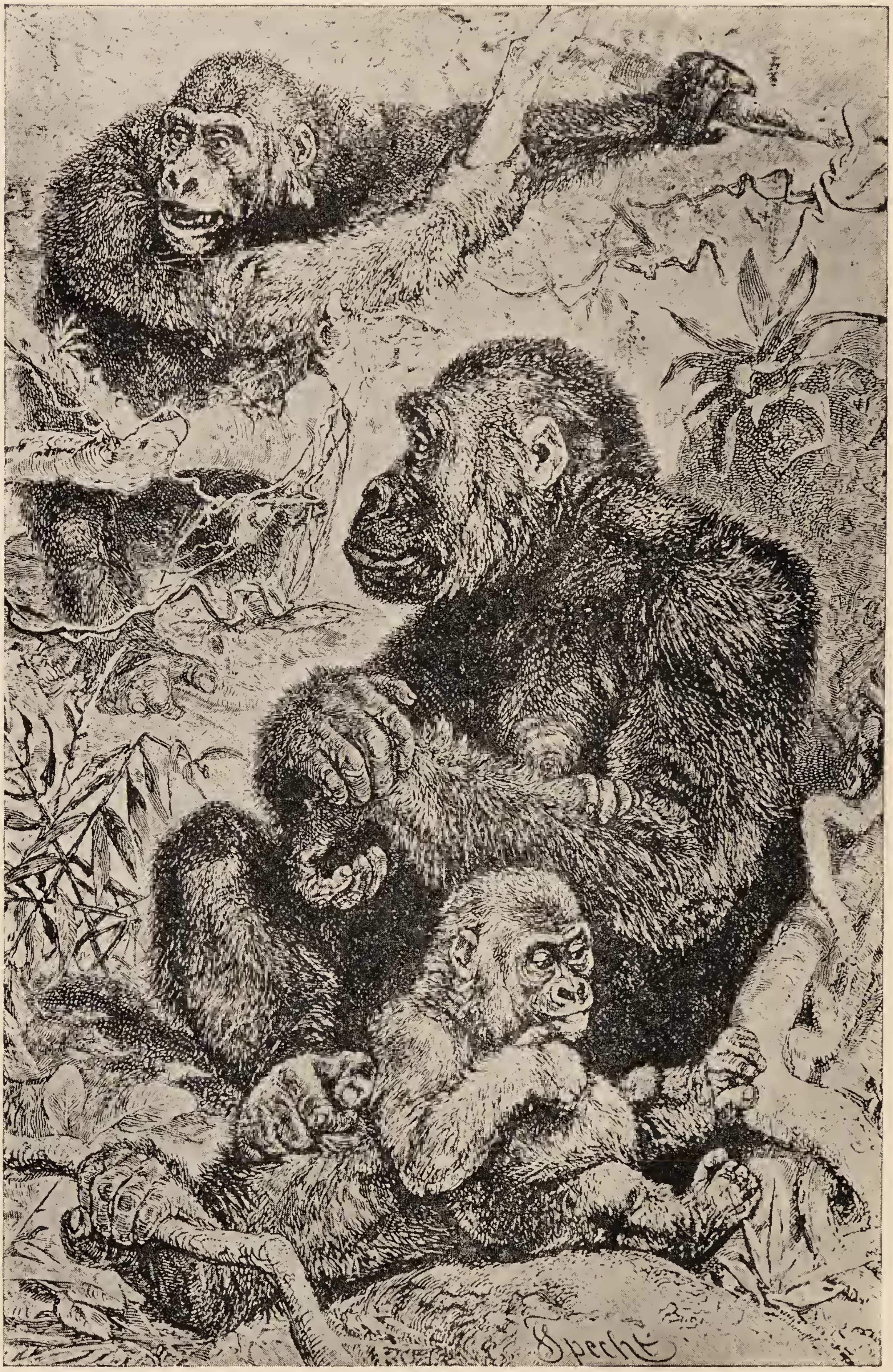


FIG. 165, Group XXI.—Gorillas at Home.

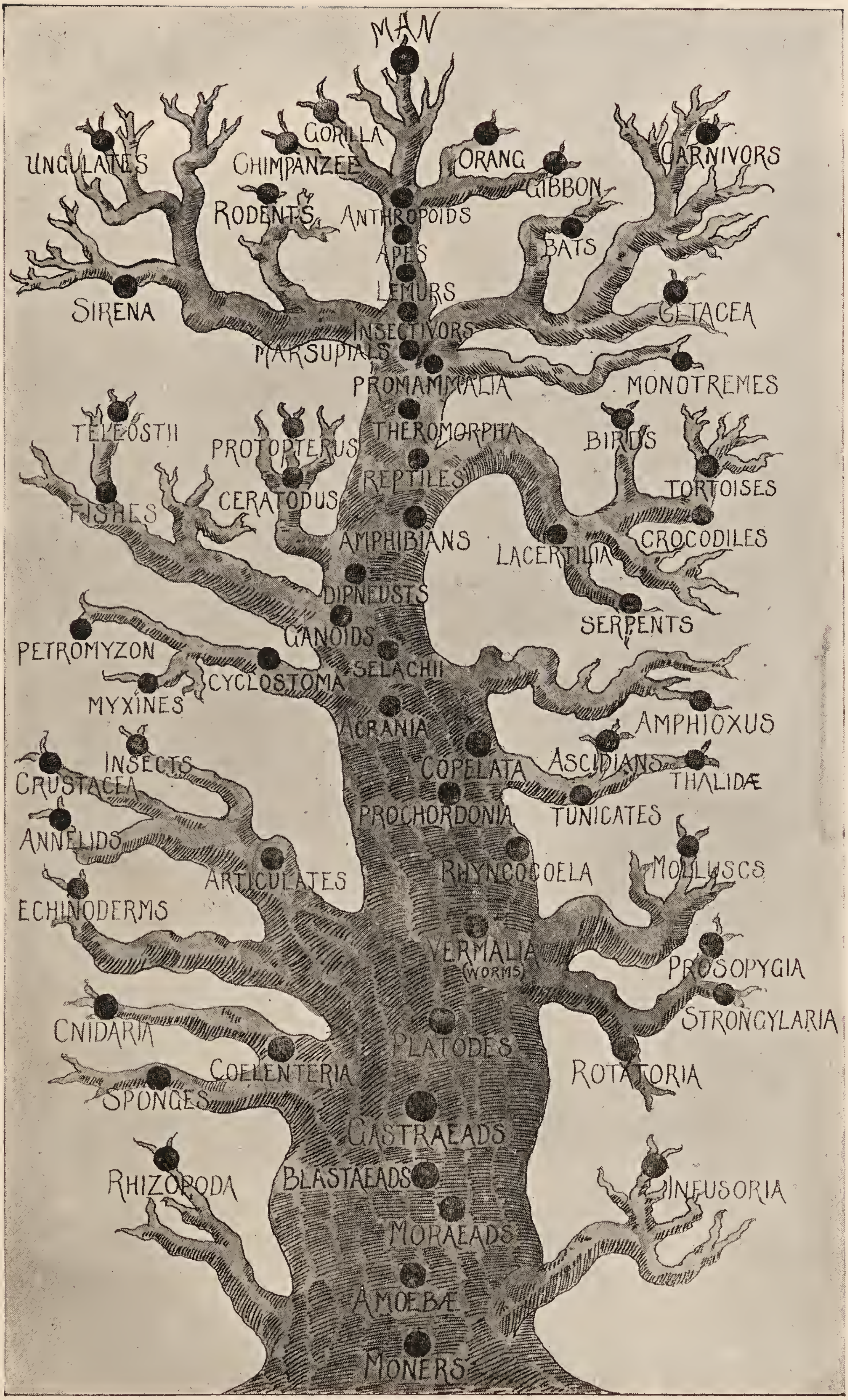

MAN
GORILLA
UNGULATES
CHIMPANZEE
ORANG
CARNIVORS
GIBBON
RODENTS
ANTHROPOIDS
BATS
APES
LEMURS
SIRENA
CETACEA
INSECTIVORS
MARSUPIALS
PROMAMMALIA
MONOTREMES
TELEOSTII
THEROMORPHA
PROTOPTERUS
BIRDS
REPTILES
TORTOISES
FISHES
CERATODUS
AMPHIBIANS
CROCODILES
LACERTILIA
DIPNEUSTS
SERPENTS
GANOIDS
PETROMYZON
SELACHII
CYCLOSTOMA
MYXINES
ACRANIA
AMPHIOXUS
INSECTS
ASCIDIANS
CRUSTACEA
COPELATA
THALIDÆ
TUNICATES
PROCHORDONIA
ANNELIDS
MOLLUSCS
ARTICULATES
RHYNCOCOELA
ECHINODERMS
VERMALIA
(WORMS)
PROSOPYGIA
STRONGYLARIA
CNIDARIA
PLATODES
COELENTERIA
ROTATORIA
SPONGES
GASTRAEADS
RHIZOPODA
BLASTAEADS
INFUSORIA
MORAEADS
AMOEBÆ
MONERS

FIG. 166.—The Genealogical Tree of Man.

and, isolating several of the members of the weaker troop, kept them prisoners. Whenever the latter tried to break out, the guards stopped them. One female, with a young one, was most viciously chased; and when, in her efforts to escape her enemies, she climbed to one of the highest limbs of a big tree, those in pursuit actually shook the branch on which she was, and jerked her to the ground. The fall was a nasty one, and in the course of the night she died. The defeated troop was thoroughly cowed.......It was plainly an incursion of a stronger troop into the domain of a weaker one; and, under mistaken counsel, the weaker hesitated too long in yielding their feeding-ground" (*Royal Natural History,* vol. i., p. 71).

CHAPTER V.

THE DISCOVERY OF EVOLUTION

ON November 25th, 1864, Mr. Disraeli (afterwards known as Lord Beaconsfield) addressed a meeting in the Sheldonian Theatre, at Oxford, in aid of the Oxford Diocesan Society. The Bishop of Oxford presided.

In his closing remarks Mr. Disraeli said :—

" It is of great importance, when this tattle about science is mentioned, that we should annex to the phrase precise ideas. I hold that the function of science is the interpretation of nature ; and the interpretation of the highest nature is the highest science. What is the highest nature ? Man is the highest nature. But I must say that when I compare the interpretation of the highest nature by the most advanced, the most fashionable, and modish school of modern science with some other teachings with which we are familiar, I am not prepared to say that the lecture-room is more scientific than the church. What is the question now placed before Society with a glib assurance the most astounding ? The question is this : Is man an ape or an angel ?

" My Lord, *I am on the side of the angels.* I repudiate, with indignation and abhorrence, the contrary view, which is, I believe, foreign to the conscience of humanity : more than that, even in the strictest intellectual point of view, I believe the severest metaphysical analysis is opposed to such a conclusion. But, on the other hand, what does the Church teach us? What is its interpretation of this highest nature? It teaches us that man is made in the image of his Creator—a source of inspiration and of solace—a source from which only can flow every right principle of morals and every divine truth. I say, therefore, that when we are told that the teachings of the Church are not consistent with the discoveries of science, and that in that sense the inferiority of the Church is shown, I totally deny the proposition. I say that the scientific teaching of the Church upon the most important of all subjects is, in fact, infinitely superior to anything that has been brought forward by any of those new discoveries. In fact, it is between these two contending interpretations of the nature of man, and their consequences, that Society will have to decide. Their rivalry is at the bottom of all human affairs. Upon our acceptance of that divine interpretation for which we are indebted to the Church, and of which the Church is the guardian, all sound and salutary legislation depends. That truth is the only security for civilisation and the only guarantee of real progress."—*Beaconsfield and His Times,* by A. C. Ewald, 1882, p. 573.

The discovery of the laws of Evolution is not the work of one man or of one age. The singularly childish remarks of a great politician which I have given at the beginning of this chapter lend some interest to the history of the discovery of Evolution. After reading Mr. Disraeli's polished ignorance, one is tempted to ask, Is the doctrine of Evolution really as silly as this? And for part of our answer we turn to a few of the illustrious men whose lives were devoted to this most illuminating discovery. We shall give no complete list of the men whose thought has revealed the method of Evolution, still less shall we give a record of those men of science whose work in other departments made it possible to understand the laws of Evolution.

Some 600 years before Christ there were men of the Ionian race who studied the origin of the universe, notably Thales and Anaximander, the Milesian (611–547). Anaximander was the first teacher of the doctrine of Abiogenesis—*i.e.,* the direct origin of living things from inorganic matter. A notable band of physicists, Heraclitus, Empedocles, Democritus, and Anaxagoras, developed some surprising anticipations of the Evolution idea.

EMPEDOCLES of Agrigentum (495–435 B.C.) held, "first, that the development of life was a gradual process; second, that plants were evolved before animals; third, that imperfect forms were gradually replaced (not succeeded) by perfect forms; fourth, that the natural cause of the production of perfect forms was the extinction of the imperfect."

DEMOCRITUS was the founder of the Atomistic philosophy and the precursor of materialism.

We have very few fragments of these great leaders of early thought; but in Aristotle we come to a much greater thinker, and we have his works from which to judge for ourselves.

ARISTOTLE (*b.* 384; *d.* 322 B.C.) may be said to have created natural history. In his books, *Physics* and *The Natural History of Animals,* he made many original observations upon plants and animals. As a boy he lived by the sea-shore, and he was early attached to natural history. "He was the first to conceive of a genetic series, and his conception of a *single chain* of evolution, from the polyps to man, was never fully replaced until the beginning of the nineteenth century."

This greatest man of Greece wrote on many things besides natural history, and, in fact, his chief influence on the world has been in other departments of thought; but when we remember that he "found no basis prepared, no models to copy," we wonder at what he did, and not at what he left undone. Could he have wholly abandoned preconceived opinions derived from his predecessors, such as Socrates and Plato, he would probably have achieved a still greater work in natural history. It has been said of him that, among many other of his discoveries, "he rightly conceived of life as the function of the organism, not as a separate principle; he anticipated Harvey's doctrine of Epigenesis in embryonic development; he fully perceived the forces of hereditary transmission, of the pre-potency of one parent or stock, and of Atavism or Reversion. He saw the fundamental difference between animals and plants, and distinguished the organic or living world from the inorganic or lifeless world."

Great is the debt we owe to Aristotle, not only for what he discovered, but far more for the method of experiment and induction by which he sought to save men from the mist of their own "intuitions."

LUCRETIUS (*b.* 95, *d.* 52 B.C.) is often praised or derided as an early poet of Evolution. He borrowed from Epicurus a sort of survival-of-the-fittest idea. This notion probably came indirectly from Empedocles. Lucretius was a Rationalist, and therefore had no place for the mythological Centaur and Chimæra in his history of creation. "He places the mechanical conception of nature over against the teleological." Though not an Evolutionist, in the sense of gradual development by descent, yet he believed in the successive appearance of different forms of life. In his grand poem, *De Rerum Natura,* he preserved the thoughts and guesses of some early thinkers, besides recording his own observations in language of great beauty.

We have not time to go through the list of the Fathers and schoolmen; but it would surprise several to learn that the great St. Augustine "distinctly rejected Special Creation in favour of a doctrine which, without any violence to language, we can call a theory of evolution" (Rev. Aubrey Moore, *Science and Faith*).

Still, no real progress in developing the doctrine of Evolution was made in the years known as "the Middle Ages." But great men, especially astronomers, were making brilliant discoveries which prepared the way for modern triumphs.

About the year 150 after Christ lived the two great astronomers Hipparchus and Ptolemy.

Ptolemy lived at Alexandria, and was the last of the great Greek astronomers. He published the *Almagest* (the Greatest), in thirteen books, in which he collected the discoveries and theories of his predecessors, and included those of Hipparchus and his own. This book became the astronomical Bible of the Middle Ages. It set forth a complicated system of cycles and epicycles to account for observed facts, and to make them square with untrue theories. Ptolemy's great error was that he taught that the earth was the centre of the heavens, and that it had no motion.

About fourteen centuries elapsed between the publication of the *Almagest* and the death of Copernicus (1543), and during this long period the greatest minds had struggled to understand the motions of the heavenly bodies on Ptolemy's wrong theory of the earth being the centre of them all. His theories had acquired an authority inconceivable to us.

COPERNICUS (Fig. 167; *b.* 1473, *d.* 1543) was born in the little trading town of Thorn, on the Vistula. Whether he was a Pole or a German will probably never be settled. He spent nine or ten years studying in Italy, and about 1497 he was made Canon at Frauenburg. He spent his life chiefly as a student, though he also practised medicine. At length it was known that he held the novel doctrine that the earth was in motion, and the sun and stars at rest. About 1531 he was ridiculed on the stage, and "Luther, in his *Table Talk,* frankly described

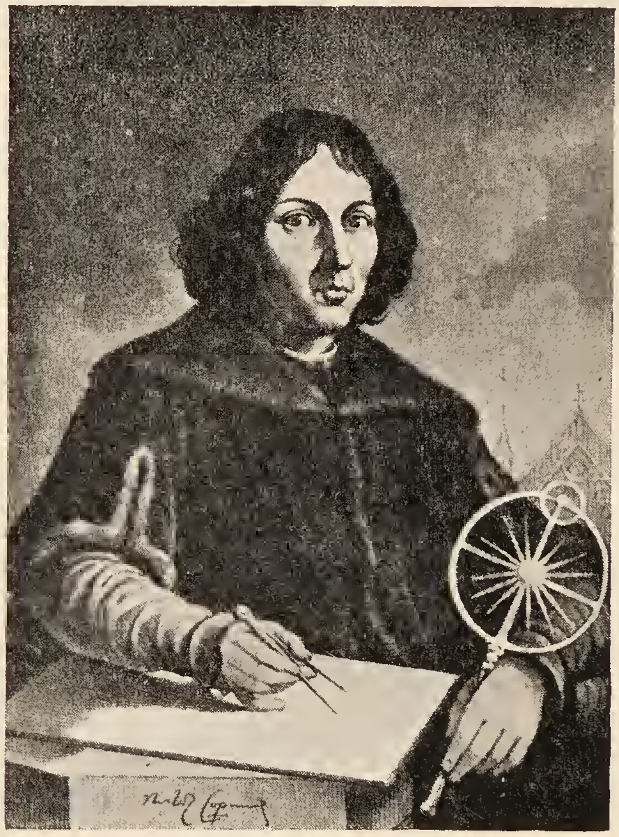


FIG. 167.—Copernicus (1473–1543).

Copernicus as a fool for holding such opinions, which were obviously contrary to the Bible; Melanchthon added to a somewhat similar criticism a broad hint that such opinions should not be tolerated." His great work was not published till the end of his life, and he received a copy of the book on the day of his death, so that he was beyond the reach of the fury of any persecutors. He had broken down the old system, and cleared the way for a true understanding of the arrangement and motions of the heavenly bodies. From his time the sun was known to be the centre of our system. Many astronomers began to work out details in the light of his great discovery.

Among these was GALILEO GALILEI, the great Italian (Fig. 168; *b.* 1564, *d.* 1642). He made many brilliant discoveries. He suffered great persecution at the hands of the Roman Catholic Church. He was finally examined, on June 21st, 1633, aged 69, under threat of torture. "He was convicted of believing and holding the doctrines—false and contrary to the Holy and Divine Scriptures—that the sun is the centre of the world, and that it does not move from east to west, and that the earth does move and is not the centre of the world." He was required to "abjure, curse, and detest the aforesaid errors," the abjuration being at once read by him on his knees; he was condemned to the "formal prison of the Holy Office" during the pleasure of his judges, and required to repeat the seven penitential psalms once a week for three years. Old and blind, he died January 8th, 1642, nearly seventy-eight years of age.

For a list of the great discoveries of Galilei it would be necessary to read a full life of him; but to us the great interest is that he accepted and improved the system of Copernicus, and thus helped to enrich the world with the great truth that the sun is the centre of our system.

We are also greatly indebted to the erratic and mystic KEPLER (Fig. 169; *b.* 1571, *d.* 1630). Though Copernicus had found the sun to be the correct centre of our system, he still made use of "the epicycles and eccentrics of the Greeks," and has been called a more orthodox epicyclist than Ptolemy himself, as he rejected the equants of the latter. It

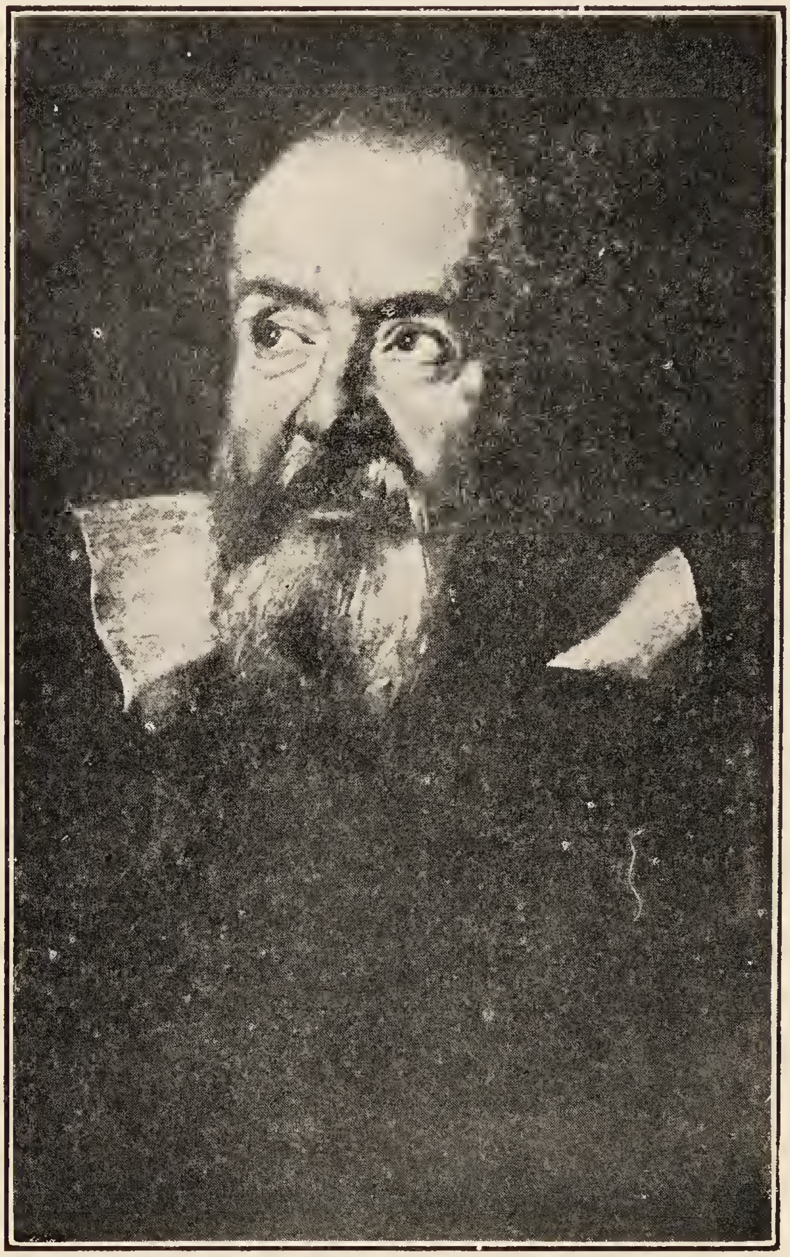


FIG. 168.—Galilei (1564–1642).

was Kepler, writing more than half-a-century later, not Copernicus, to whom the rejection of the epicycle and eccentric is due. For thus re-stating and amending the great discovery of Copernicus the world is greatly indebted to Kepler.

Many other workers and observers succeeded Kepler; but no astronomical discovery of first-rate importance was published after Galilei's *Two New Sciences* (1638) till Newton's *Principia* appeared in 1687.

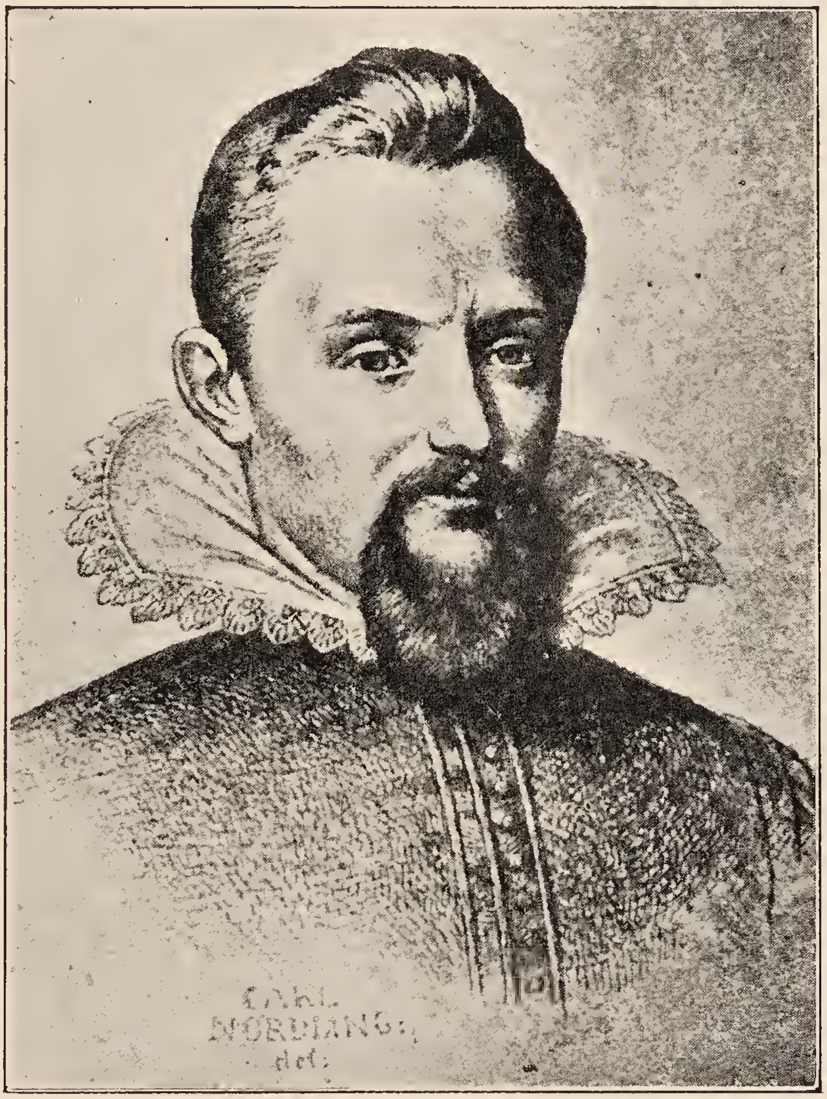


FIG. 169.—Kepler (1571–1630).

ISAAC NEWTON (Fig. 170; *b.* 1642, *d.* 1727) accomplished most remarkable work in astronomy, optics, and pure mathematics. He stands forth as one of the greatest men of all time. We are here concerned with his brilliant discovery of the Law of Gravitation, which may be stated thus in its most general form : "Every particle of matter attracts every other particle with a force proportional to the mass of each, and inversely proportional to the square of the distance between them."

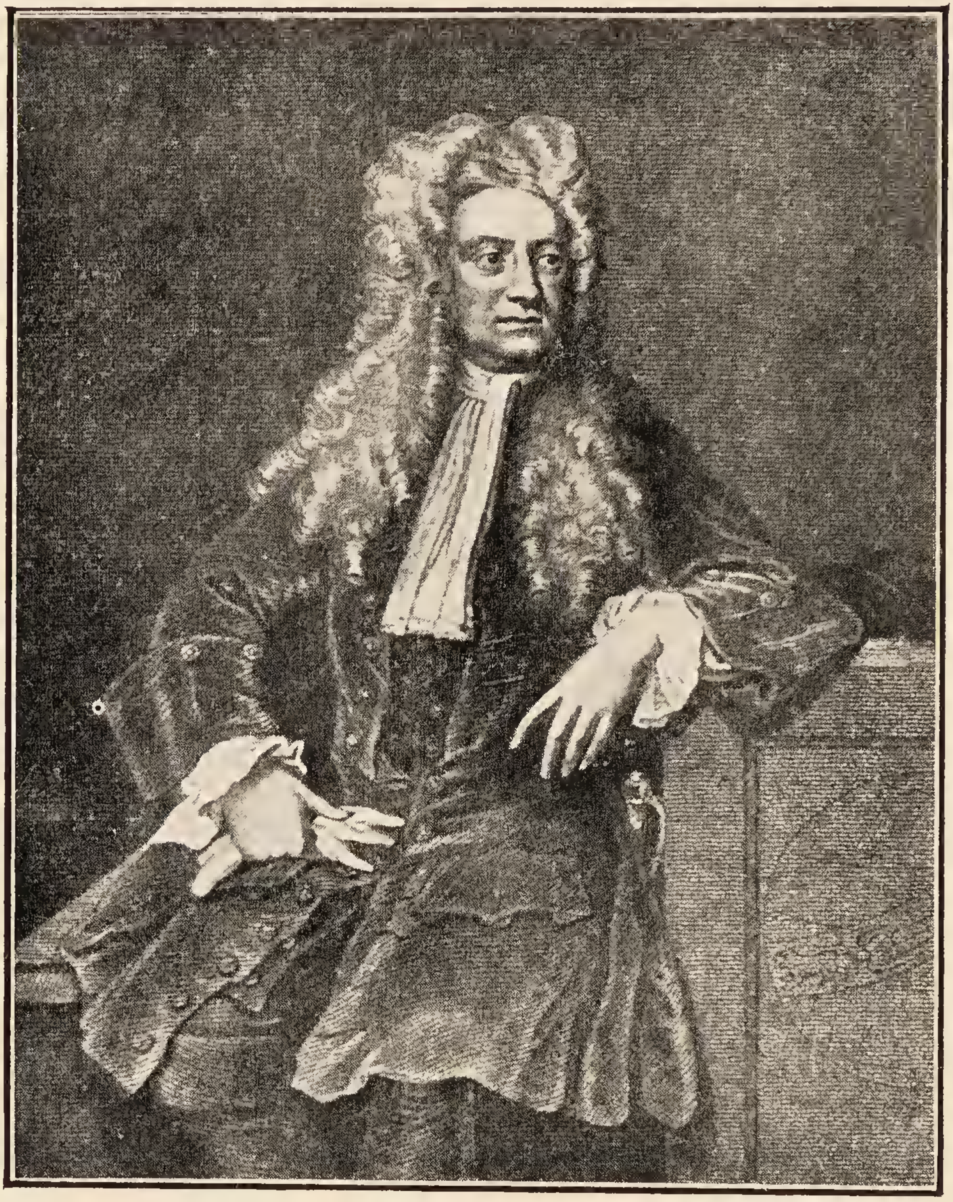


FIG. 170.—Newton (1642-1727).

Other astronomers had toiled to show *how* the heavenly bodies moved ; Newton discovered *why*. Of course, he held that the sun was the centre of our system ; but he did not hold that "it was at *rest* in the centre of the world." He proved "that in any system of bodies, such as the solar system, moving about in any way under the influence of their mutual attractions, there is a particular point, called the *centre of gravity,* which can always be treated as at rest." The sun moves relatively to this point.

The important fact for us, with regard to these discoveries, is that they prepared the way for the Nebular Hypothesis. (See *Picture Book,* Part I., pp. 32–37.)

There are five great discoveries, in the history of the world, which are of universal application ; they might be called the five miracles of the human brain. They are :—

1. The Law of Gravitation. (See Newton.)
2. The Nebular Hypothesis. (See Kant, Laplace, and Herschel, in Part I.)
3. The Indestructibility of Matter. (See Lavoisier.)
4. The Indestructibility of Energy. (See Mayer and Helmholtz.)
5. The Laws of Evolution. (See Darwin, Wallace, Spencer, Huxley, Haeckel.)

The Nebular Hypothesis has now become a part of the doctrine of Evolution in its widest sense. We not only know how man came into existence, but we know how stars and planets came into existence, and we know *why* they move as they do.

A. L. LAVOISIER (Fig. 171 ; *b.* 1743, murdered 1794), one of the founders of modern chemistry, was born in Paris of a wealthy family. He made many discoveries, but his fame rests on his greatest achievement, by which he proved that matter is indestructible. This is one of those great revolutions in thought, the full results of which we have not yet seen. For, if matter has no end, it seems but a fair inference that it had no beginning; and the eternity of matter would be a factor which would overturn most systems of philosophy. Lavoisier, probably on account of his connection with the

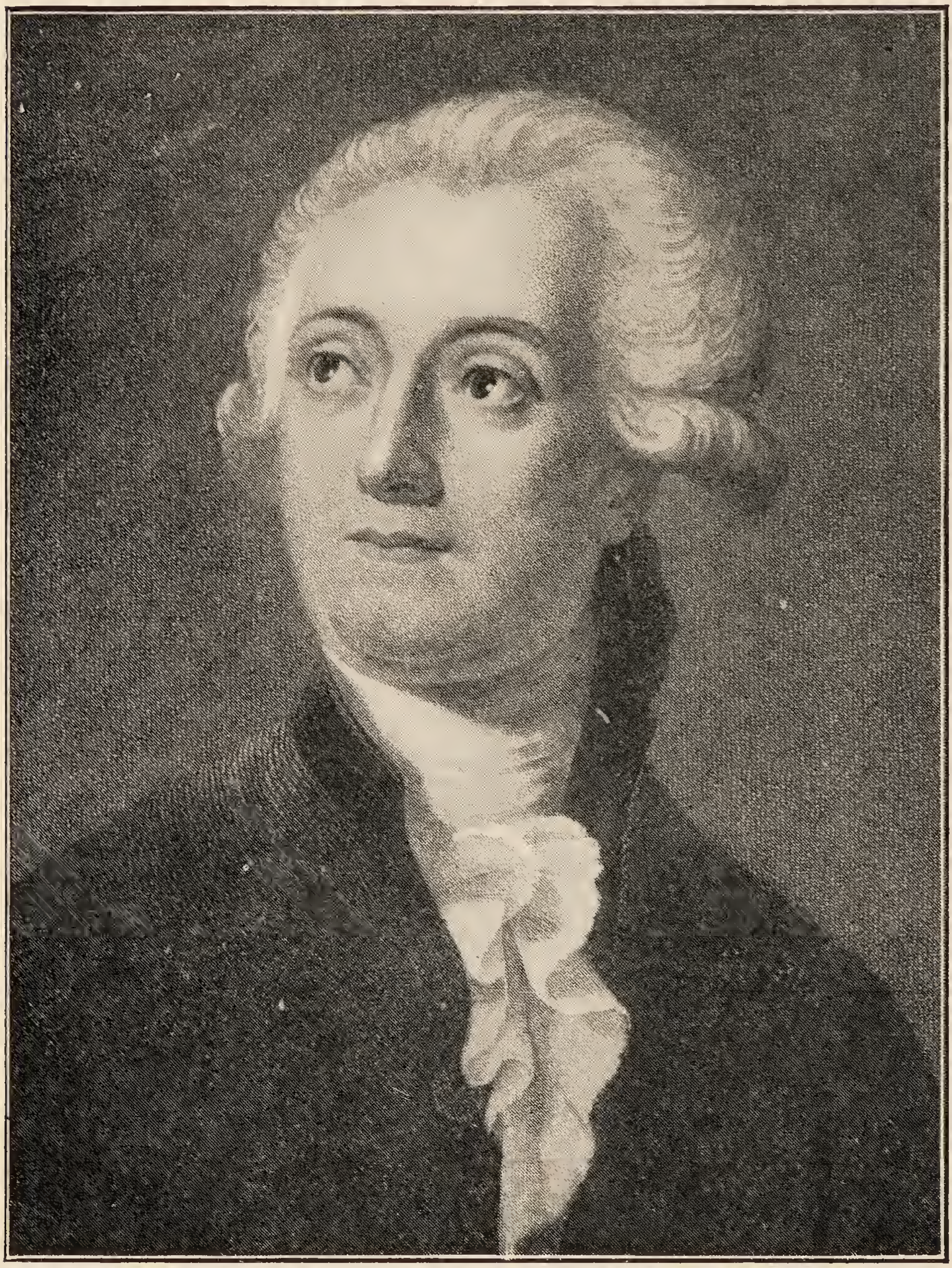


FIG. 171.—Lavoisier (1743–1794).

former government, was guillotined, and thus perhaps the greatest life in France was lost.

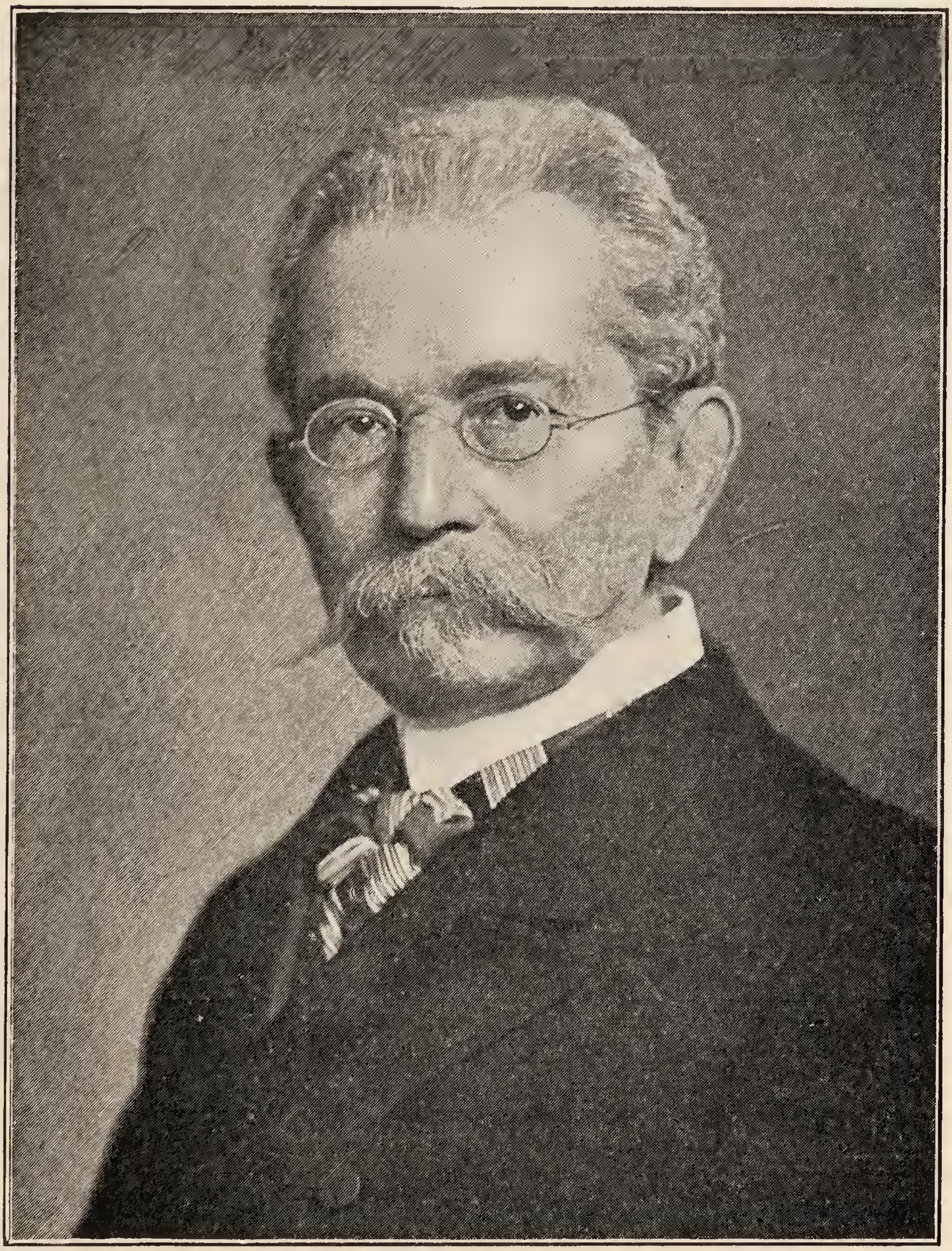


FIG. 172.—Mayer (1814–1878).

JULIUS ROBERT MAYER (Fig. 172 ; *b.* 1814, *d.* 1878) was born at Heilbronn, where he afterwards settled as a physician. In 1842 he completed the revolution of Lavoisier by discovering the conservation of energy; in other words, he showed that energy, like matter, is indestructible.

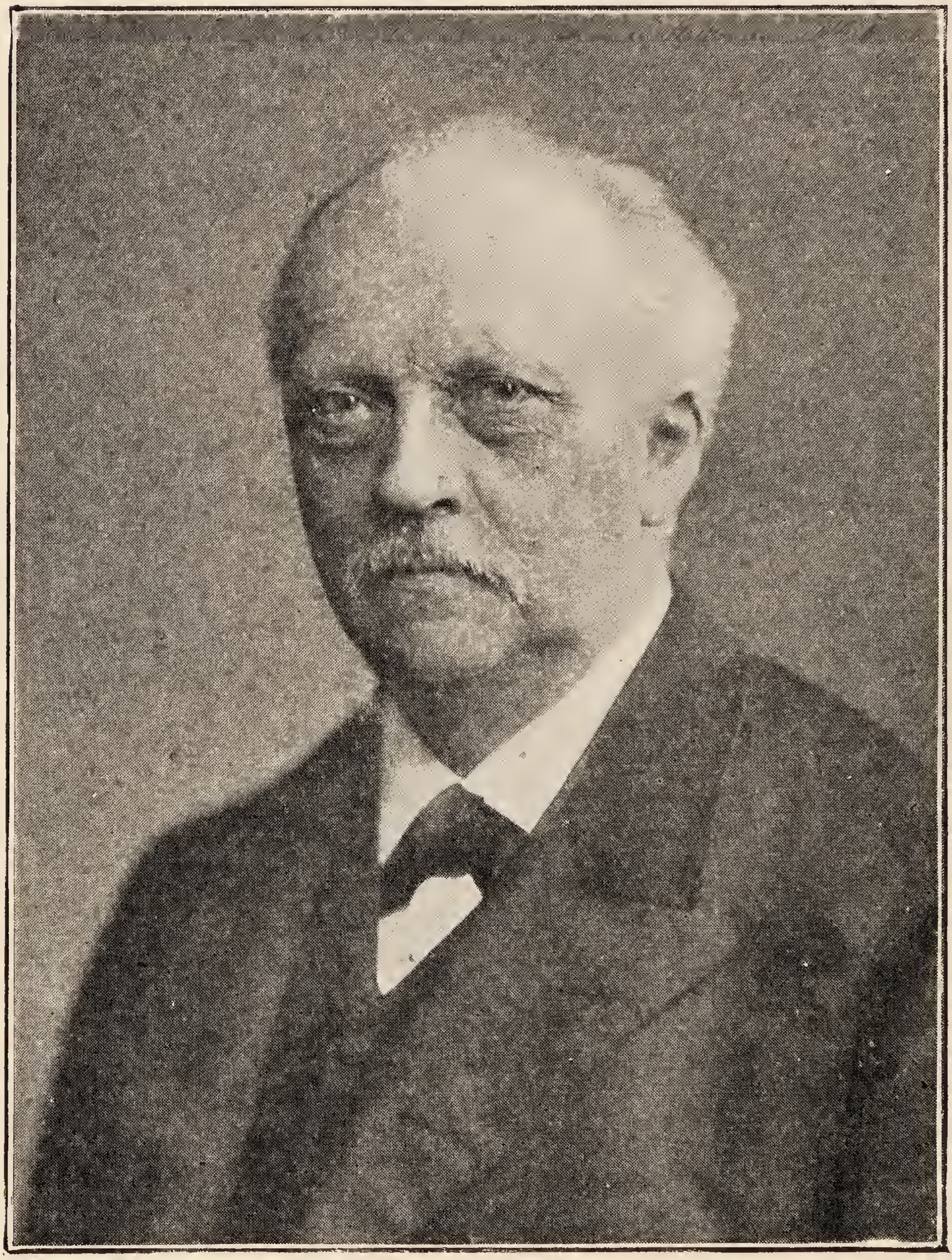


FIG. 173.—Helmholtz (1821–1894).

Quite independently, H. L. FERDINAND VON HELMHOLTZ (Fig. 173; *b.* 1821, *d.* 1894), the distinguished German physician, discovered the conservation of energy in 1847, when he was professor of physics at Berlin.

MATTHIAS SCHLEIDEN (Fig. 174; *b.* 1804, *d.* 1881), born at Hamburg, studied at Heidelberg, and afterwards at other universities, and became professor of botany at Jena (1846–1850). He

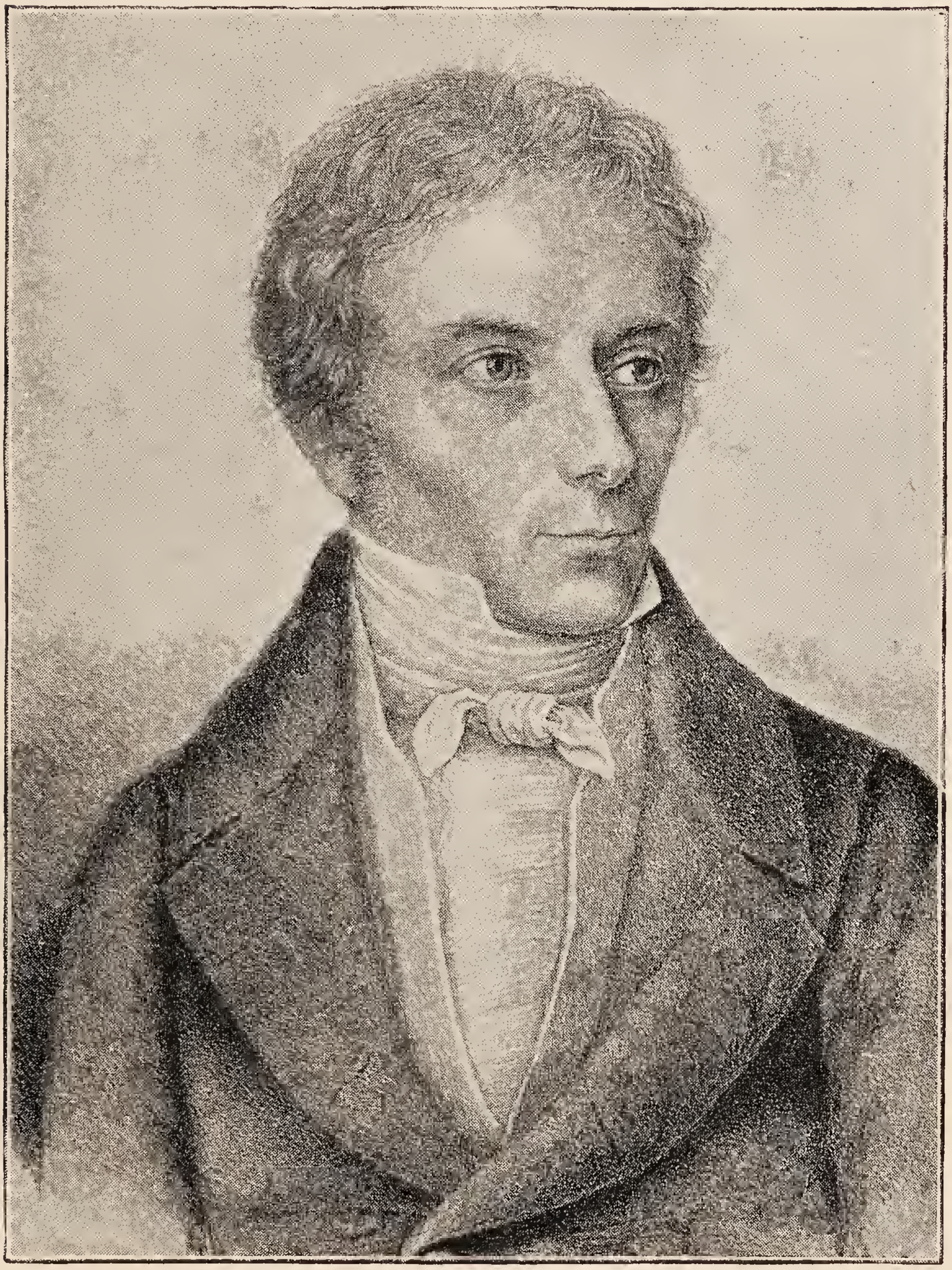


FIG. 174.—Schleiden (1804–1881).

proved "that a nucleated cell is the only original constituent of the plant embryo, and that the development of all vegetable tissues must be referred to such cells, thus preparing the way for the epoch-making cell theory of Schwann." He died at Frankfurt. He was distinguished in many branches of science; but this discovery of cell-growth was his greatest achievement.

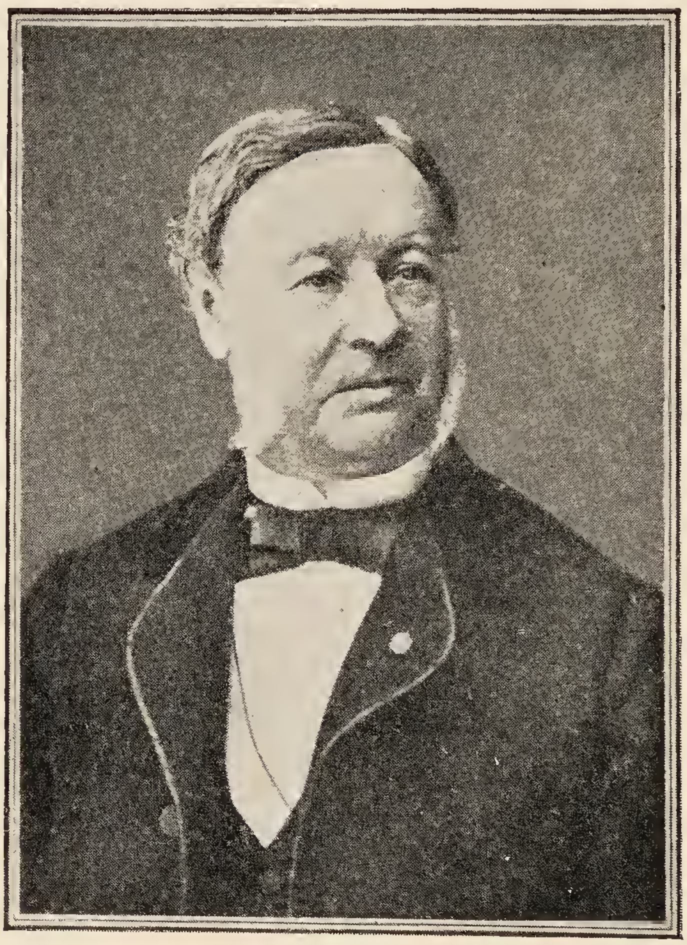


FIG. 175.—Schwann (1810–1882).

THEODOR SCHWANN (Fig. 175; *b.* 1810, *d.* 1882) was born at Neuss, in Rhenish Prussia, on December 7th. He studied at Cologne and Bonn, and afterwards at Berlin, where he graduated in 1834. In 1838 he became professor of anatomy at Louvain.

At Berlin he had assisted the great Johannes Müller in his physiological experiments. Here he did his most valuable work. He was the first of Müller's pupils who broke with the traditional vitalism and worked towards a physico-chemical explanation of life. He discovered the true theory of fermentation.

Once, when dining with Schleiden in 1837, the conversation turned on the nuclei of vegetable cells. Schwann remembered having seen similar structures in the cells of the notochord, and he instantly seized the importance of connecting the two phenomena. The resemblance was confirmed without delay by both observers, and in 1839 he published his famous work, *Microscopic Investigation on the Accordance in the Structure and Growth of Plants and Animals.* To this great discovery may be traced the wonderful developments by Pasteur, Lister, and Virchow, and the knowledge of the causes of fertilisation. He died at Liége, where he was professor, on January 11th, 1882.

After this brief account of discoveries of some of the great laws which prepared the way for the demonstration of the doctrine of Evolution, we may turn to those naturalists who also prepared the way for the signal discoveries of Darwin, Wallace, and Spencer.

LINNÆUS, the famous Swedish naturalist (Fig. 176; 1707–1778), wrote a great work, the *Systema Naturæ,* which was the turning-point in modern zoology and botany. He was an industrious collector of facts, and wrought great changes in classification. His attempt was to arrange animals in a *natural system,* or a divine order of things. He at first held "the absolute fixity of species from the period of their creation as described in Genesis"; but in 1762 we find his views somewhat altered, and when he published the revised edition of his great work in

1766 he had left out his fundamental proposition of the earlier works, that *there were no new species*. Perhaps we cannot now realise what it meant to be able to think that there might be such a thing as a new species!

Born but four days after Linnæus, **Buffon** (1707–1788) may be called the naturalist who was founder of the modern applied form of the Evolution theory. He laid the basis of modern Evolution in zoology and botany. "He first pointed out, on a broad scale, the mutability of species in relation to changes of environment." On classification he was quite opposed to Linnæus. By 1761 he had come to believe in the frequent mutability of species, both by development and degeneration, though he withdrew from this position, to some extent, later. It is not possible to discuss him in any detail here. He distinctly helped in the discovery of Evolution.

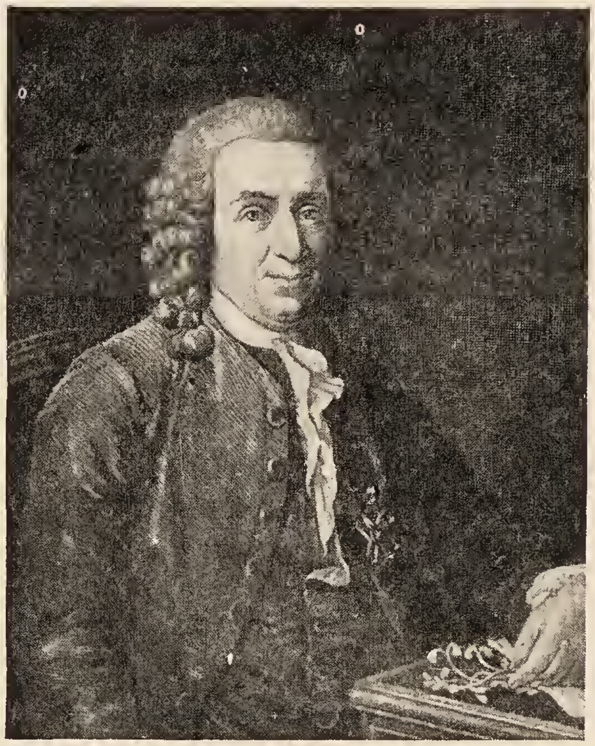


FIG. 176.—Linnæus (1707–1778).

A bolder Evolutionist than Buffon was his contemporary ERASMUS DARWIN (Fig. 177; 1731–1802), grandfather of Charles Darwin. "He was the first who proposed and consistently carried out a well-rounded theory with regard to the development of the living world."

Erasmus Darwin was born at Elton, near Newark. He studied in London and Edinburgh, and settled as a doctor at Lichfield. He expressed his thoughts on world-history and zoology in poems, and also wrote a prose work, *Zoonomia* (1794–1796). He rejected the current belief in the separate creation of species. In his *Zoonomia,* after summarising the extraordinary adaptations to be seen in the animal kingdom, he asks: "Would it be too bold to imagine that all warm-blooded animals have arisen from one living filament which the great First Cause endued with

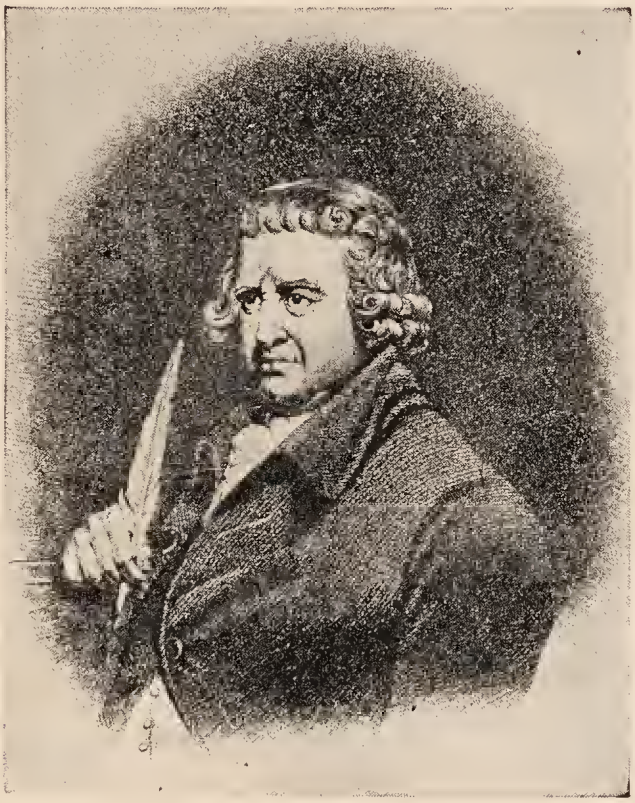


FIG. 177.—Erasmus Darwin (1731–1802).

animality, with the power of acquiring new parts, attended with new propensities, directed by irritations, sensations, volitions, and associations?" Later he inquires: "Shall we conjecture that one and the same kind of living filament is and has been the cause of all organic life?"

He anticipated Lamarck in the importance he attached to use and disuse, expressed his belief in the inheritance of acquired characters, and recognised the importance of sexual selection.

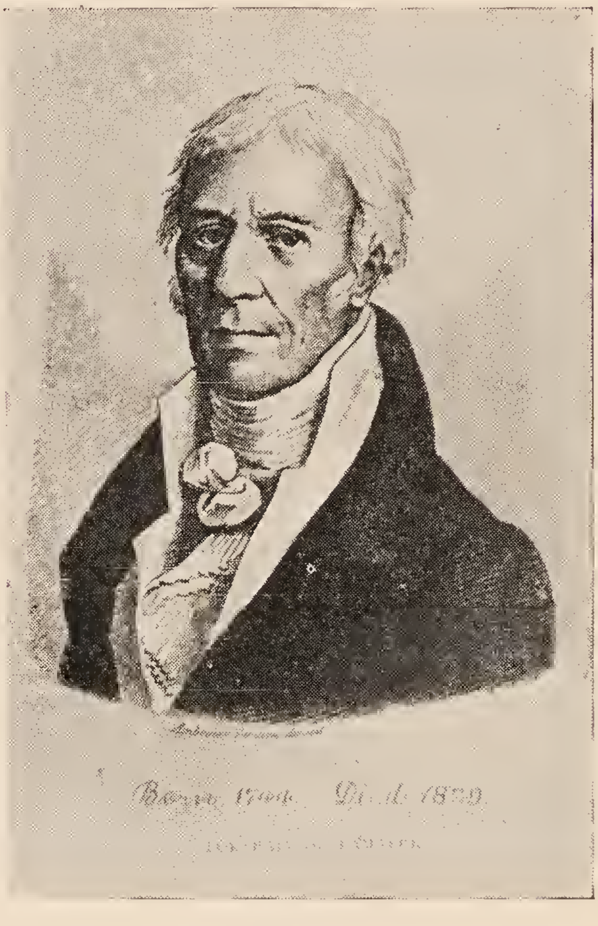

Born 1744. Died 1829.

FIG. 178.—Lamarck (1744–1829).

Grant Allen says that the theory of "Natural Selection was the only cardinal one in the evolutionary system on which Erasmus Darwin did not actually forestall his more famous and greater namesake."

J. B. P. A. DE LAMARCK (Fig. 178; 1744–1829) "was not only a distinguished general zoologist and palæontologist, but may also be looked upon as the chief of the pre-Darwinian evolutionists. In his *Philosophie Zoologique,* published in 1809 (the year in which Charles Darwin was born), he completely rejected the idea of the fixity of species, and endeavoured to explain the transformation of one form into another by the operation of known causes ; of these he attached most importance to the principle of use and disuse, and he was a firm believer in use-inheritance. He believed that the history of the earth and of its past inhabitants is to be explained by the action of the causes seen in operation to-day, and not by catastrophes. He considered also that the transformation of species took place by slow, orderly changes, Nature requiring only matter, space, and time in order to effect her various changes. He introduced the terms 'vertebrata' and 'invertebrata,' and, in the same year (1802) as Treviranus, proposed the term 'biology' for the science of living things."

Lamarck at first believed in a linear classification of animals, but afterwards adopted the earliest known branching or phylogenetic classification. The exact value of Lamarck's contribution to the doctrine of Evolution has not yet been determined, as some of his principles are still debated ; but he has at least the "glory of having for the first time worked out the theory of Descent." Poor, neglected, and blind in his old age, he died in 1829.

Lamarck's contemporary GEOFFROY ST. HILAIRE supported the hypothesis of Evolution, though differing from Lamarck on some points. But his other contemporary, GEORGES CUVIER (1769–1832), though a great scientist, rejected the theory of Evolution and ridiculed Lamarck. And, as Cuvier was on the side of authority, he dominated zoological science for half a century—to the loss of his country.

Fig. 179.—Goethe (1749–1832).

Goethe (Fig. 179; 1749–1832), the great German poet, was a keen supporter of Evolution. He introduced the term "morphology," and made important contributions to that department. In 1790, when he "picked up the skull of a slain victim from the sand of the Jewish cemetery at Venice, he noticed at once that the bones of the face also could be traced to vertebræ (like the hindmost cranial vertebræ)." (See Oken, Fig. 180, and Gegenbaur, Fig. 188.)

He recognised the importance of vestigial organs, and predicted the presence of a premaxilla in man—the absence of that bone in the *adult* human skull being hitherto considered as distinctively separating Man from the other Primates!

Lorenzo Oken (Fig. 180; 1779–1851), born at Baden, professor at Zurich, wrote many contradictory things, but became famous for his doctrine of "the Ur-Schleim"—viz., "Every organic thing has arisen out of slime, and is nothing but slime in different forms. This primitive slime originated in the sea, from inorganic matter, in the course of planetary evolution."

This, in the main, is probably true; but he is noticed here, not only for this famous doctrine, but also because he was one of the first to see that the skull of man is developed from the back-bone. He was wrong on many points; but his great discovery remained, and was finally corrected and established by Gegenbaur (see Fig. 188). This is known as the famous vertebral theory of the skull, and was discovered independently by Goethe and Oken. So far the doctrine of Evolution had not succeeded in gaining acceptance in the scientific world; but many men were preparing the way.

William Smith (1769–1839), the English geologist, showed that the older fossils belonged to entirely different species and genera from the families existing at the present day. In this way the idea of a definite succession of life in time was introduced, though Cuvier and his school held that the fauna of each epoch was destroyed by some convulsion of nature, and the earth subsequently re-peopled by a fresh creative act! This view of the history of the earth received its death-blow in

FIG. 180.—Oken (1779-1851).

1830–1833, when Sir CHARLES LYELL (1797–1875) (see Fig. 96, Part I.) published his *Principles of Geology.* Next to the *Origin of Species,* this is the most famous contribution to natural science in modern times.

K. E. VON BAER (1792–1876), a Russian biologist, discovered the ovum of mammals in 1827; he also described the three primary germ-layers—ectoderm, mesoderm, and endoderm—in the vertebrate embryo. He enunciated "von Baer's law," that development is a progress from the general to the special. This law had a most important effect upon Herbert Spencer's thinking.

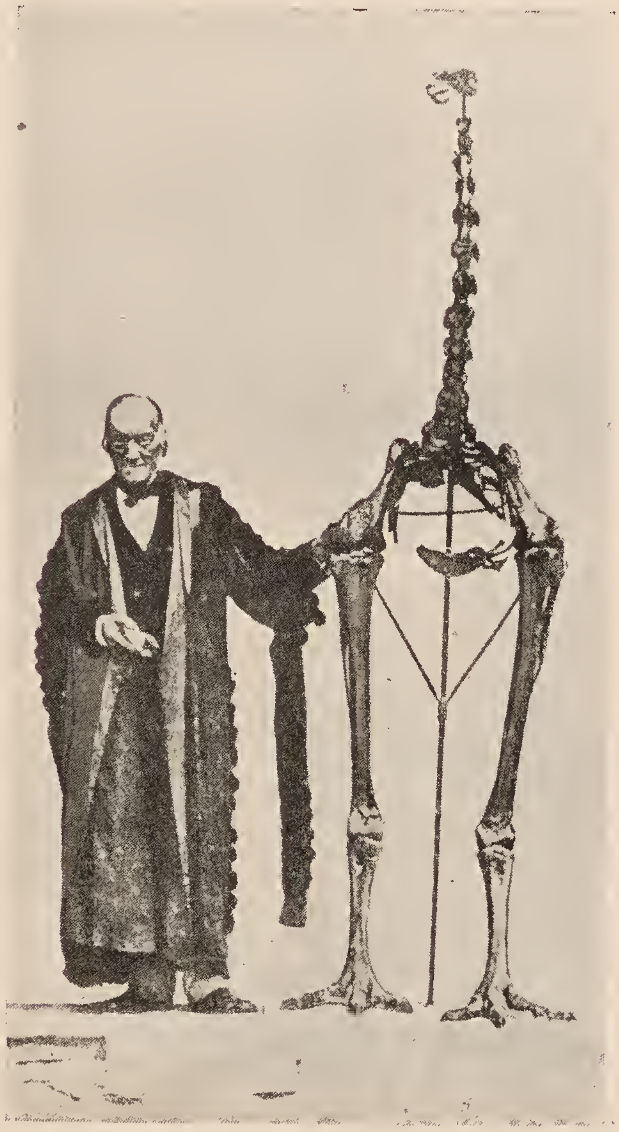


FIG. 181.—Richard Owen (1804–1892).

Sir RICHARD OWEN (Fig. 181; 1804–1892) had resuscitated the vertebral theory of the skull, freed it from absurdities, and developed it. He made numerous other brilliant anatomical researches.

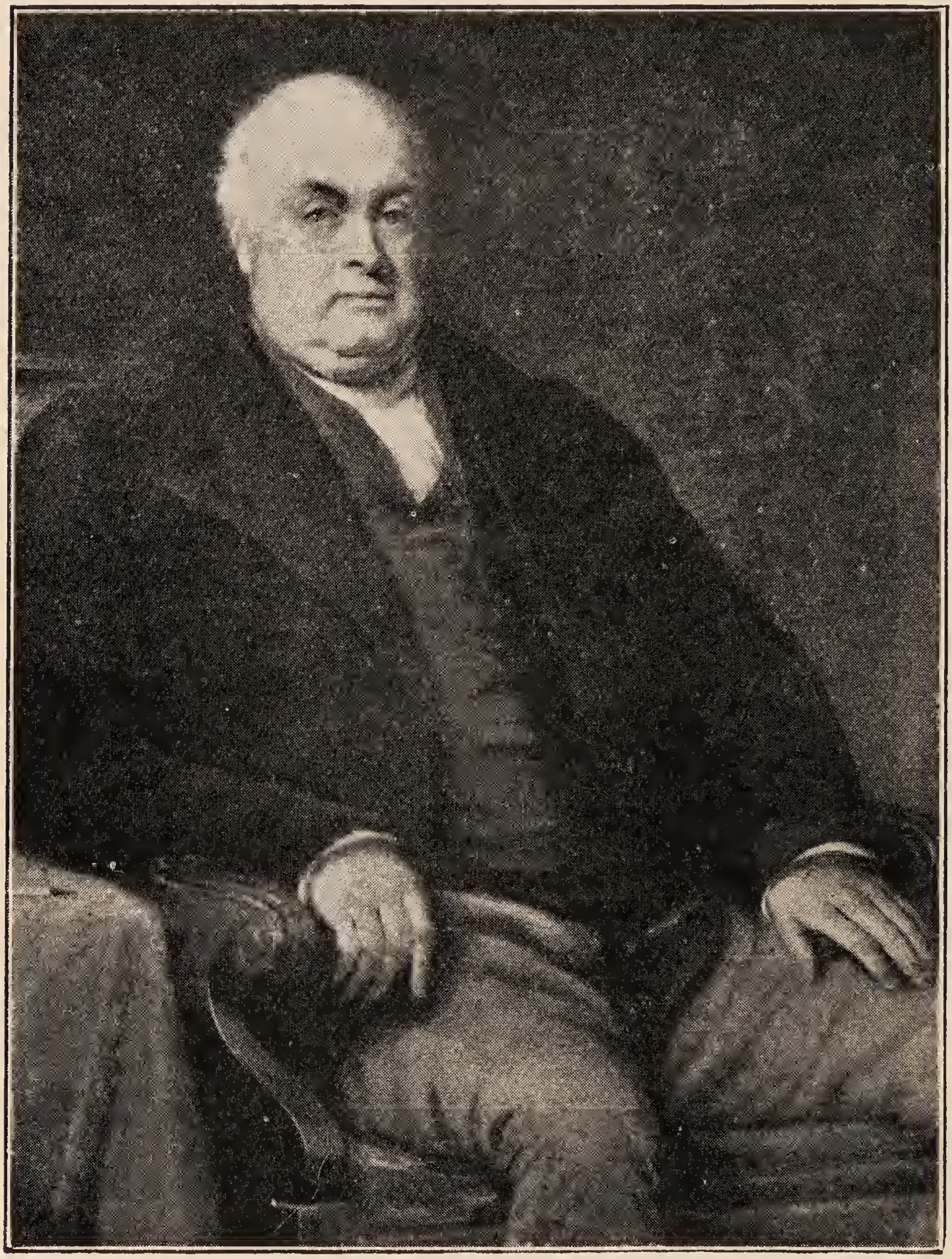


FIG. 182.—Robert Waring Darwin (1766–1848).

He could not accept Darwin's great discovery. A host of others, too numerous to be named here, were slowly opening up the world of fact.

On November 24th, 1859, occurred what may fairly be called the most important event in the history of biological science—the publication of CHARLES DARWIN'S (Fig. 183; *b.* February 12th, 1809; *d.* April 19th, 1882) *Origin of Species.* "We have seen that former evolutionary theories did not produce a great effect." But Darwin had the

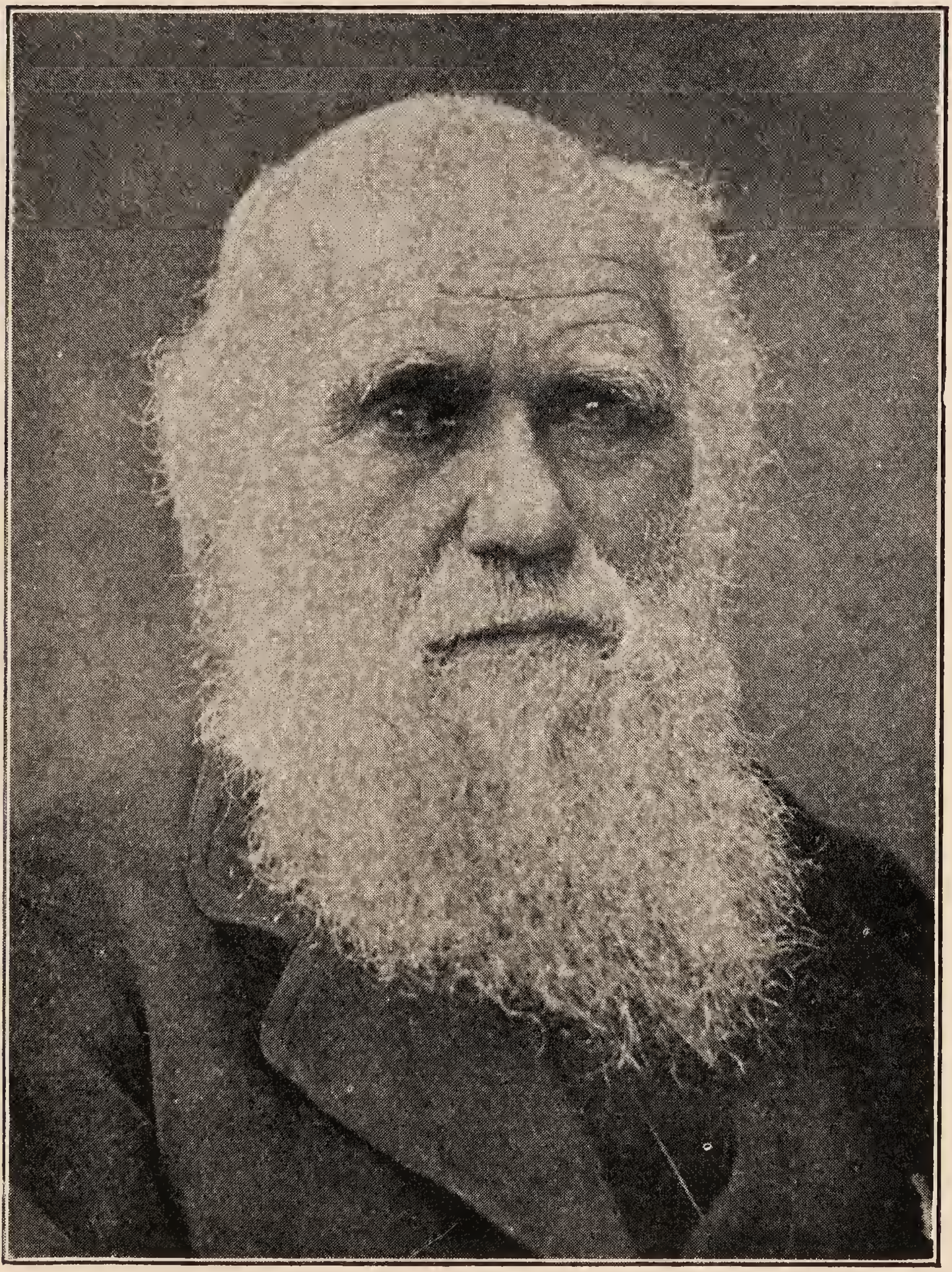


FIG. 183.—Charles Darwin (1809–1882).

advantage of being not only a philosopher, but a naturalist in the broadest sense. It is not surprising, therefore, that the wealth of illustration, the close reasoning, and the philosophic spirit of the

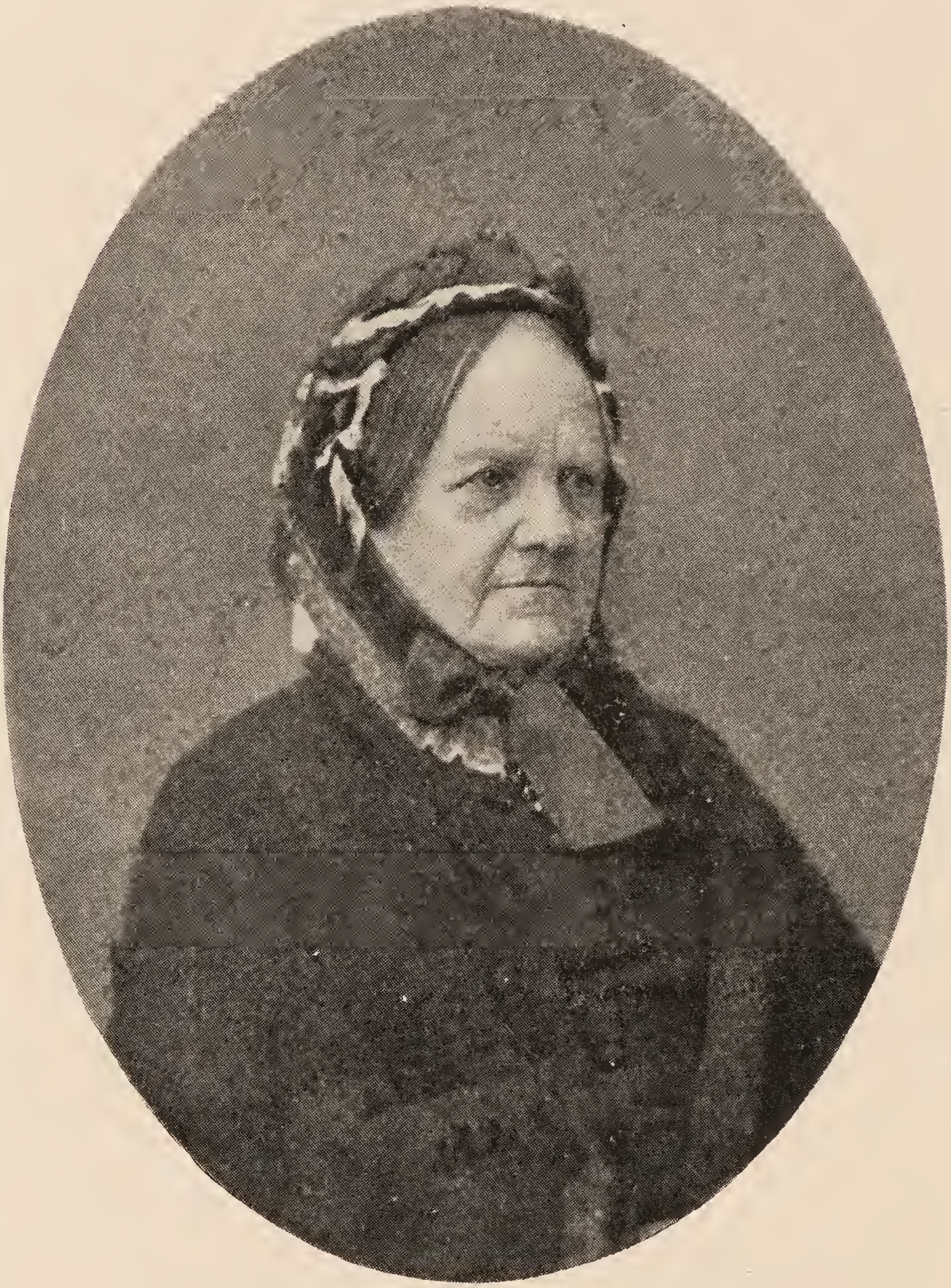


Fig. 184.—Mrs. Charles Darwin (1808–1896).

Origin of Species converted the whole scientific world to the general doctrine of transformism within twenty years. The theory of Natural Selection, the Survival of the Fittest, or the

Preservation of favoured races in the Struggle for life, was first grasped by Darwin in 1838, but was not published till 1858, when it was announced at the same time by himself and Alfred Russel Wallace. Both these authors had, however, been anticipated by Dr. W. C. Wells in 1813, and by Patrick Matthew in 1831, though neither Darwin nor the scientific world knew anything of either of them. But, whatever others may have discovered, "Darwin first made men believe it." (See pp. 188–198, Part I.) For an account of this most wonderful man, read the life by his son, Francis Darwin (Murray, 2s. 6d.).

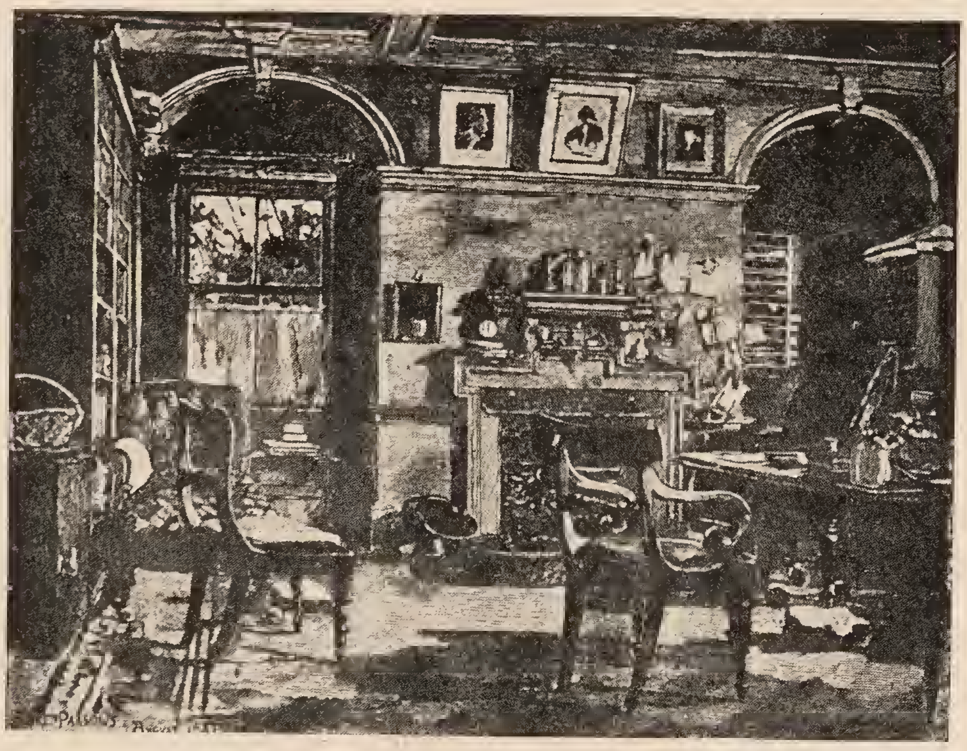


FIG. 185.—Darwin's Study at Down.

His father (Fig. 182) was Dr. Robert Waring Darwin, of Shrewsbury. Charles Darwin's mother was Susannah, daughter of Josiah Wedgwood, the great potter. Dr. Darwin died November 13th, 1848. Darwin often spoke of his father as "the wisest man I ever knew."

On January 29th, 1839, Charles Darwin married his first cousin, EMMA WEDGWOOD (Fig. 184). She died in October, 1896. In 1842 Darwin went to live at Down, near Beckenham. Here he suffered much in health; but he patiently toiled on, and in the STUDY AT DOWN (Fig. 185) he altered the centre of gravity of thought, and verily "lifted empires off their hinges."

ALFRED RUSSEL WALLACE (Fig. 186; born at Usk in Monmouthshire, January 8th, 1823), after travelling with Bates along the river Amazon, and making collections of natural-history specimens, sailed in 1854 for the Malay Archipelago for the same purpose. When lying ill with fever at Ternate, in February, 1858, something led him to think of the "positive checks" described by Malthus in his essay on *Population*. He says: "There suddenly flashed on me the *idea* of the survival of the fittest, and in the two hours that elapsed before my ague fit was over I had thought

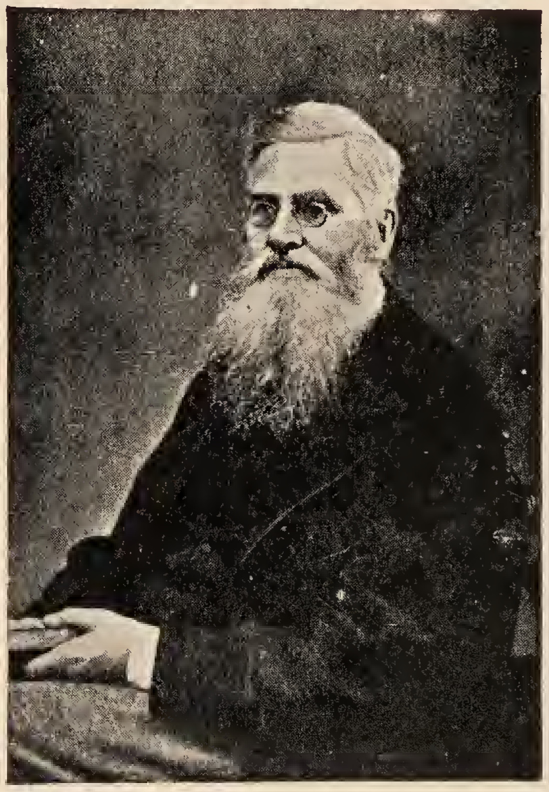


FIG. 186.—Alfred Russel Wallace (*b.* 1823).

out the whole of the theory, and in the two succeeding evenings wrote it out in full, and sent it by the next post to Mr. Darwin."

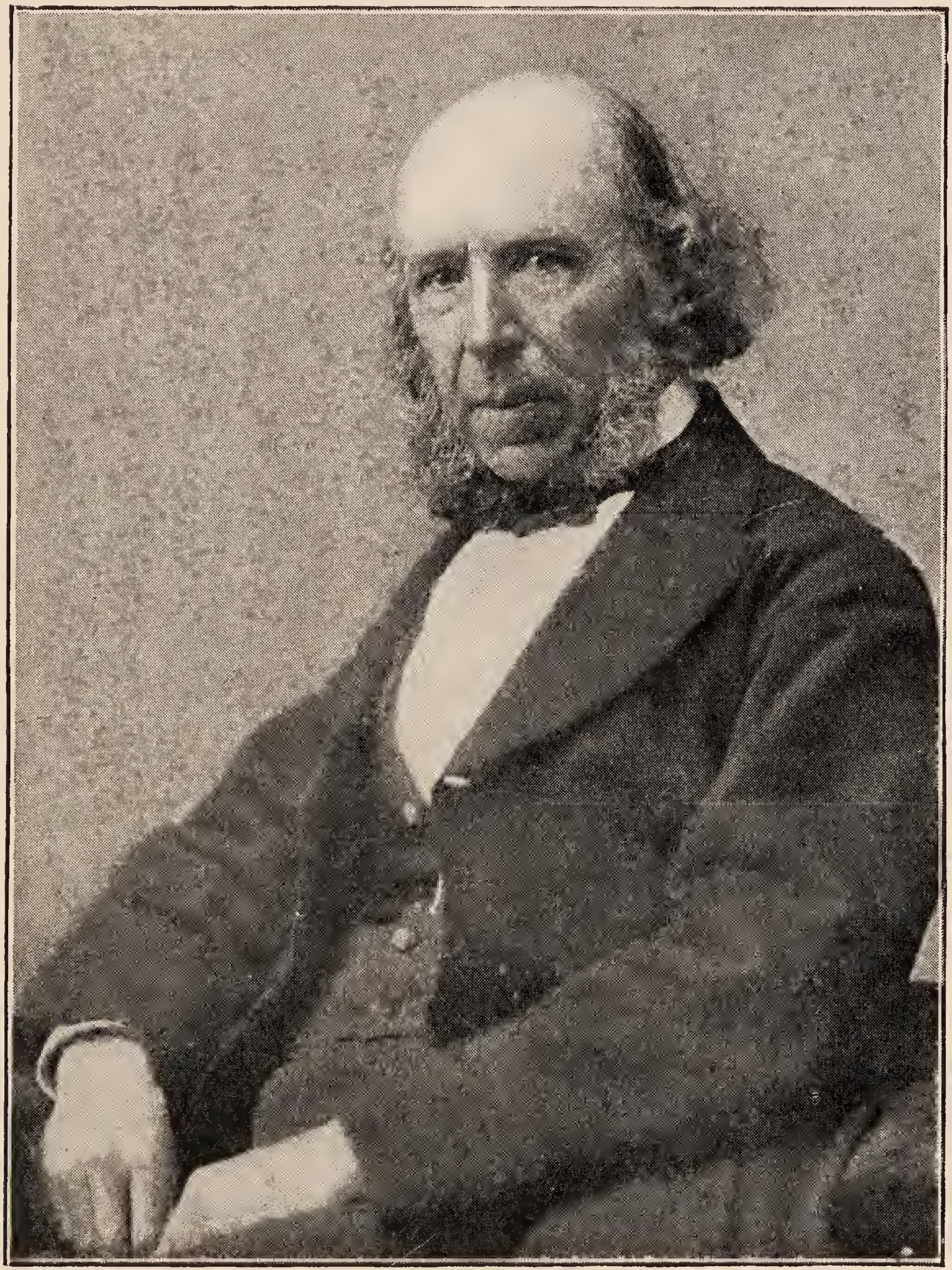


FIG. 187.—Herbert Spencer (1820–1903).

It is remarkable that both Darwin and Wallace should have independently discovered the same theory, and have expressed it in almost the same words, and that they should have *suddenly* hit upon it in thinking over the same book.

Darwin wrote a short paper (an abstract of the *Origin*), and this abstract was read with Wallace's paper at a meeting of the Linnean Society on July 1st, 1858.

But seven years before Darwin published the *Origin of Species* a young man had written a paper giving a clear presentation of the general doctrine of evolution. This was HERBERT SPENCER (Fig. 187; born at Derby on April 27th, 1820; died at Brighton on December 8th, 1903. In the *Principles of Biology* (1863–1866) he gave the theory of organic evolution a philosophic expression. He used the phrase "survival of the fittest," instead of Natural Selection. It is marvellous that he was so near discovering Natural Selection, and yet did not. He gave his life to establishing the great principle of Organic Evolution, and to applying it to physical, biological, psychological, and social facts. His works are a monument of genius and industry.

KARL GEGENBAUR (Fig. 188; *b.* August 21st, 1826; *d.* June 14th, 1903) is described by Haeckel as "the comparative anatomist who surpassed all other experts of this science, in the second half ot the nineteenth century, by the richness of his empirical knowledge and the acuteness and depth of his philosophic speculations." His great work is *Studies of the Comparative Anatomy of the Vertebrates*. In 1872, after seven years' labour, he solved the problem with regard to the famous vertebral theory of the skull. The older theory, as stated by Oken and Goethe, had been refuted by Huxley and others; but their errors arose chiefly from their mistaken way in approaching the proof formed from the head-part of the perichordal axial of the theory. "Nevertheless, there remained the fundamental idea of it—the belief that the skull is skeleton (*i.e.*, from the back-bone), just as the brain is from the simple medullary tube, by differentiation and modification."

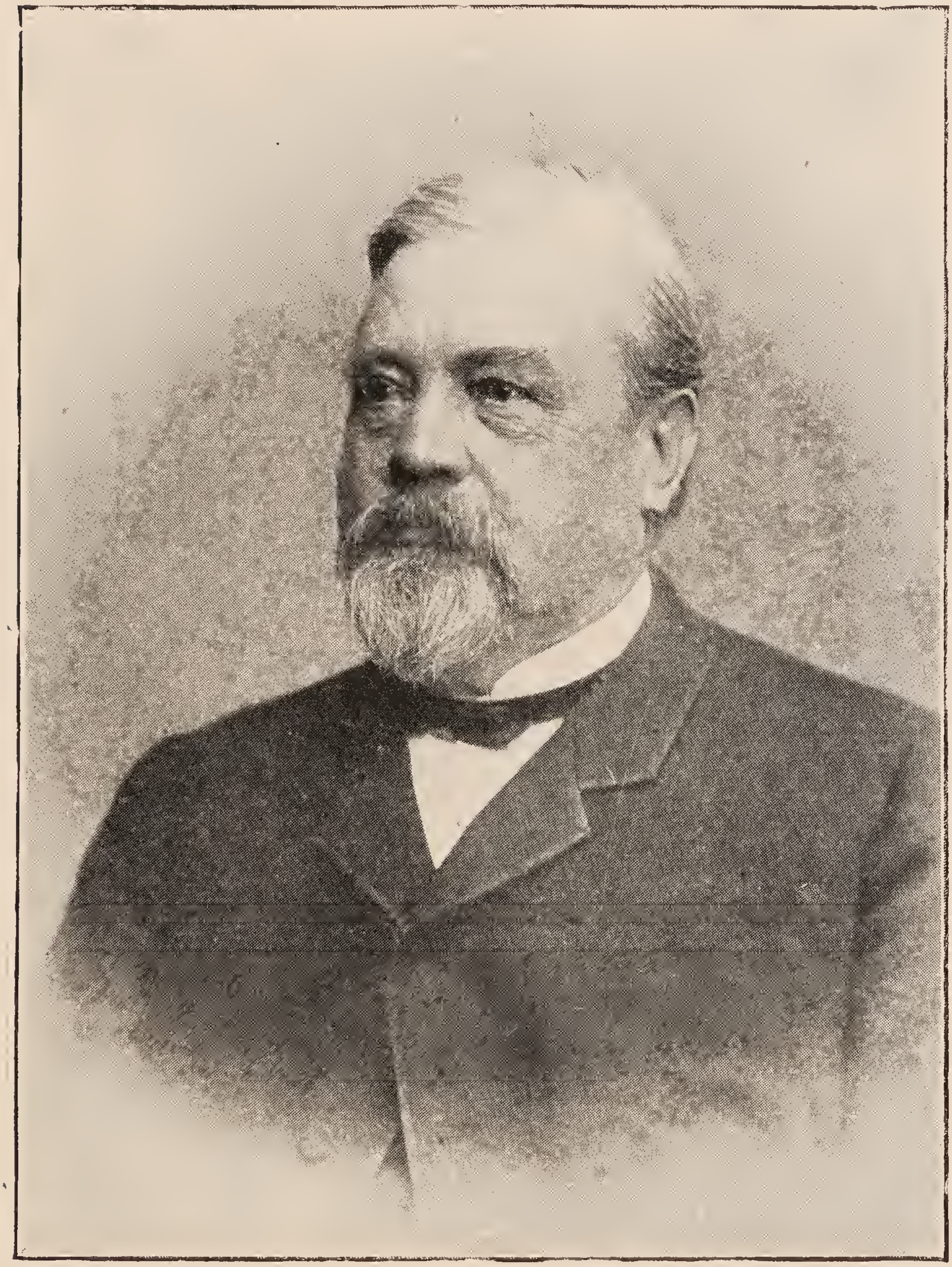


FIG. 188.—Karl Gegenbaur (1826–1903).

Gegenbaur's proof of this remarkable fact is one of his most interesting contributions to science. He showed that the nerves proceeding from the base of the brain are modifications of spinal nerves.

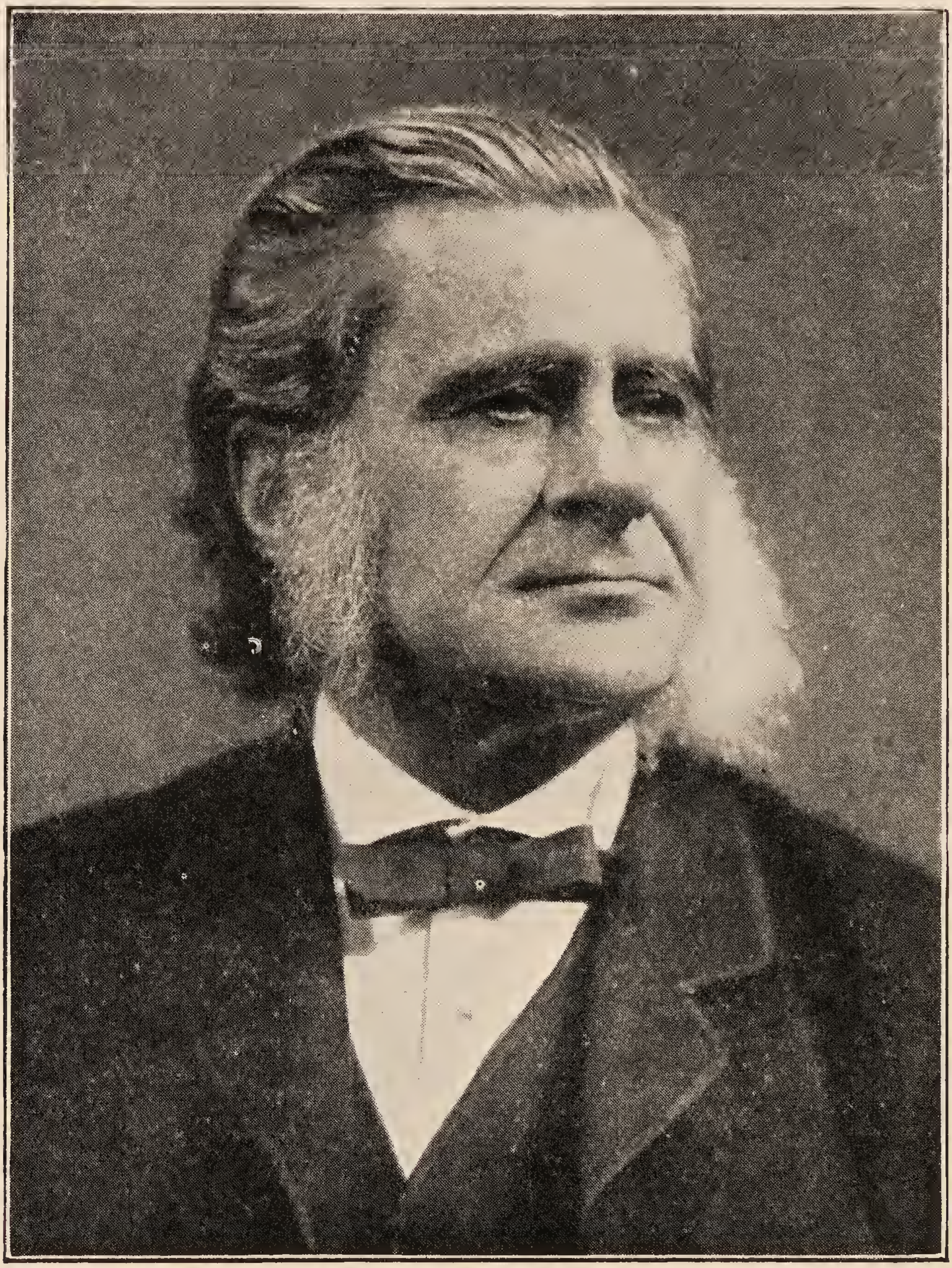


FIG. 189.—Thomas Henry Huxley (1825–1895).

(See Haeckel's *Evolution of Man,* vol. ii., pp. 300, 301, for a fuller account.)

THOMAS HENRY HUXLEY (Fig. 189; *b.* at Ealing

May 4th, 1825; *d.* June 29th, 1895) ranks as one of the foremost of the discoverers and teachers of Evolution. His wonderful ability, industry, fearlessness, and eloquence fitted him for the position of leader in the war against prejudice which broke out immediately on the publication of Darwin's *Origin of Species*. No sketch of a few lines can do any justice to Huxley; therefore it is not here attempted. It must suffice to say that the cause of truth is indebted to Huxley in no ordinary degree,

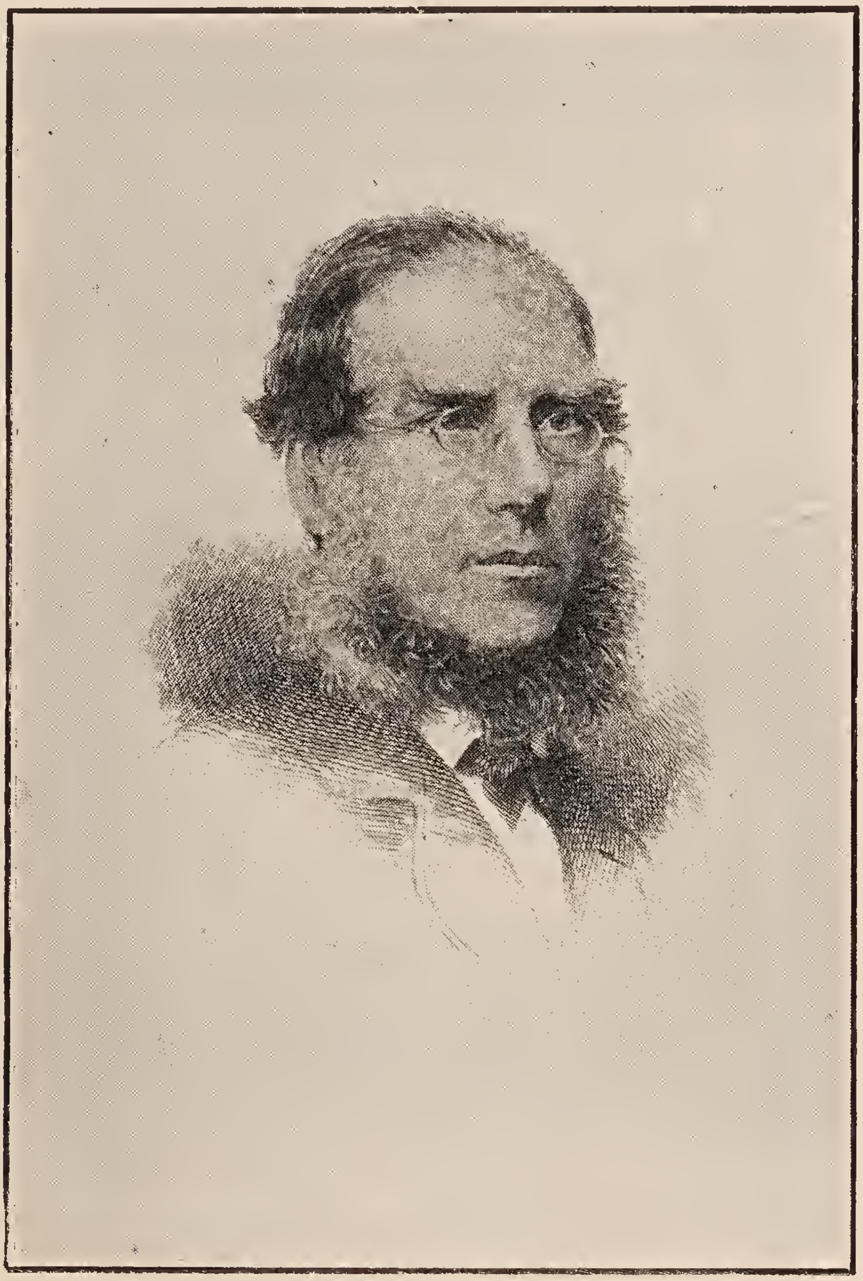


FIG. 190.—Sir J. D. Hooker (*b.* 1817).

and that probably there was no man then living who could have achieved so much in England, on behalf of science, as he did. Darwin said in one of his letters that there were three judges by whose decision he determined to abide. These three were Lyell, Hooker, and Huxley.

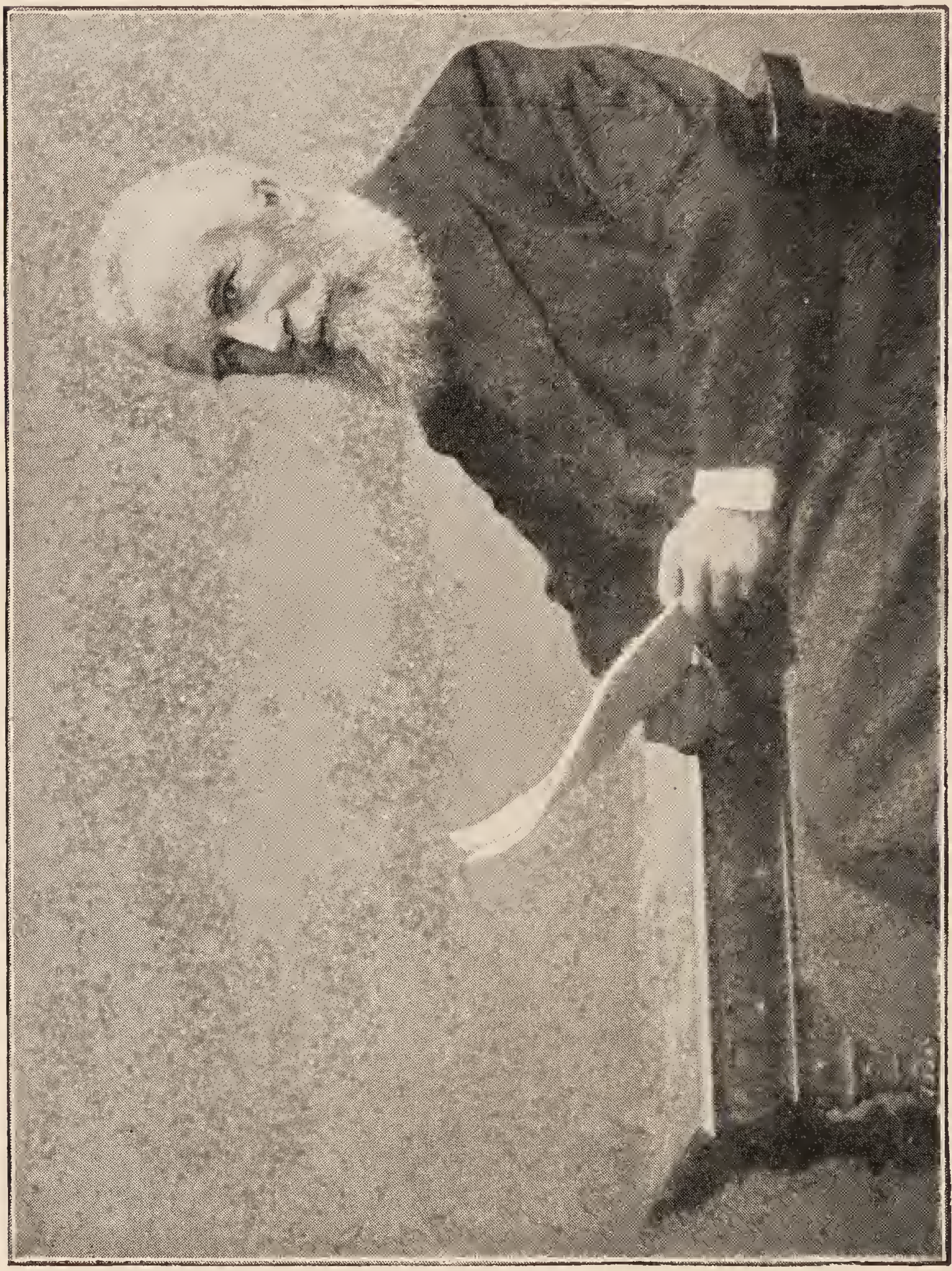


FIG. 191.—Ernst Haeckel (*b.* 1834).

SIR JOSEPH DALTON HOOKER (Fig. 190; *b.* at

Halesworth, Suffolk, 1817) was a great botanist. He travelled much, and greatly added to our knowledge of the distribution of plants. He was director of Kew Gardens for twenty years. Often elected President of the British Association, in that capacity (1868) he supported the views of Darwin on Evolution, which was of enormous value.

Perhaps the greatest living (1907) Evolutionist is Ernst Haeckel (Fig. 191), born at Potsdam, 1834. His original contributions to the demonstration of Evolution are too numerous to be set down here. He is a man of many accomplishments, marvellous industry, and quite fearless. He was the first German to accept the discovery of Darwin, and he has done more than anyone in Germany to demonstrate its truth and to teach it. " He was the first modern zoologist to attempt the classification of animals on a frankly evolutionary basis. We owe to him the terms 'phylogeny' and 'ontogeny,' 'cœnogenesis' and 'palingenesis,' and

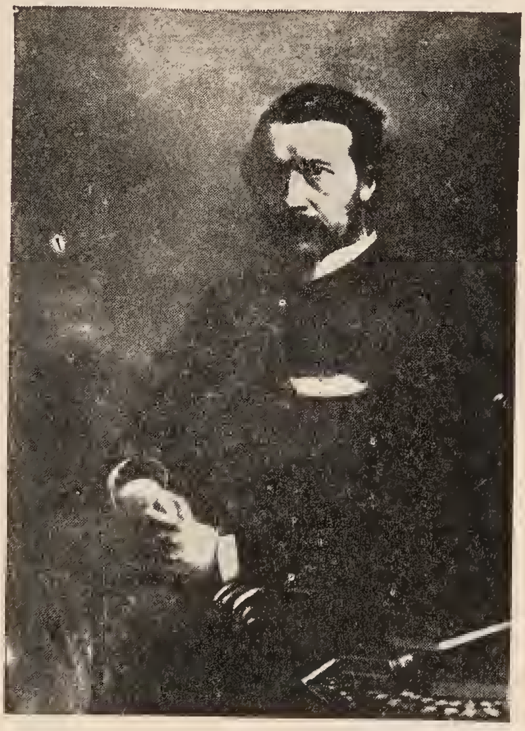


Fig. 192.—George John Romanes (1848–1894).

the fruitful gastræa theory, according to which the gastrula is the ancestral form of all the Metazoa." Two of his great books are *The Natural History of Creation* and *The Evolution of Man.* His two books, *The Riddle of the Universe* and *The Wonders of Life,* are of a more popular character, and have produced a great effect throughout Europe, and especially in Great Britain.

George John Romanes (Fig. 192 ; *b.* Kingston, Canada, 1848 ; *d.* May 23rd, 1894), in his great work, *Darwin and after Darwin,* rendered valuable service. This book, rich in fine illustrations, has been of immense help in preparing *The Picture Book of Evolution.* He also lectured on Evolution, and wrote important books on certain religious questions. Perhaps his greatest work is *Animal Intelligence.*

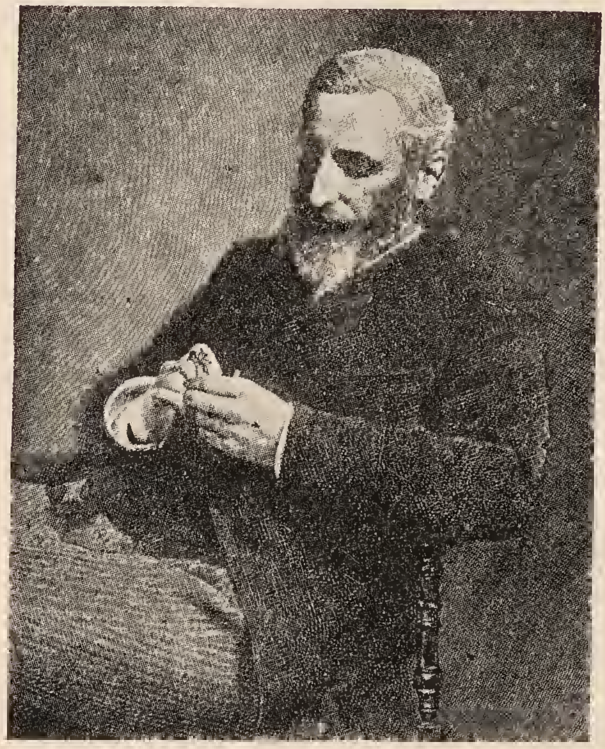


Fig. 193.—Charles Grant Allen (1848-1899).

Charles Grant Allen (Fig. 193; *b.* Kingston, Canada, February 24th, 1848 ; *d.* 1899) was a remarkable combination of scientist and novelist. Had his health and means permitted, he was capable of great things as a scientist. He wrote

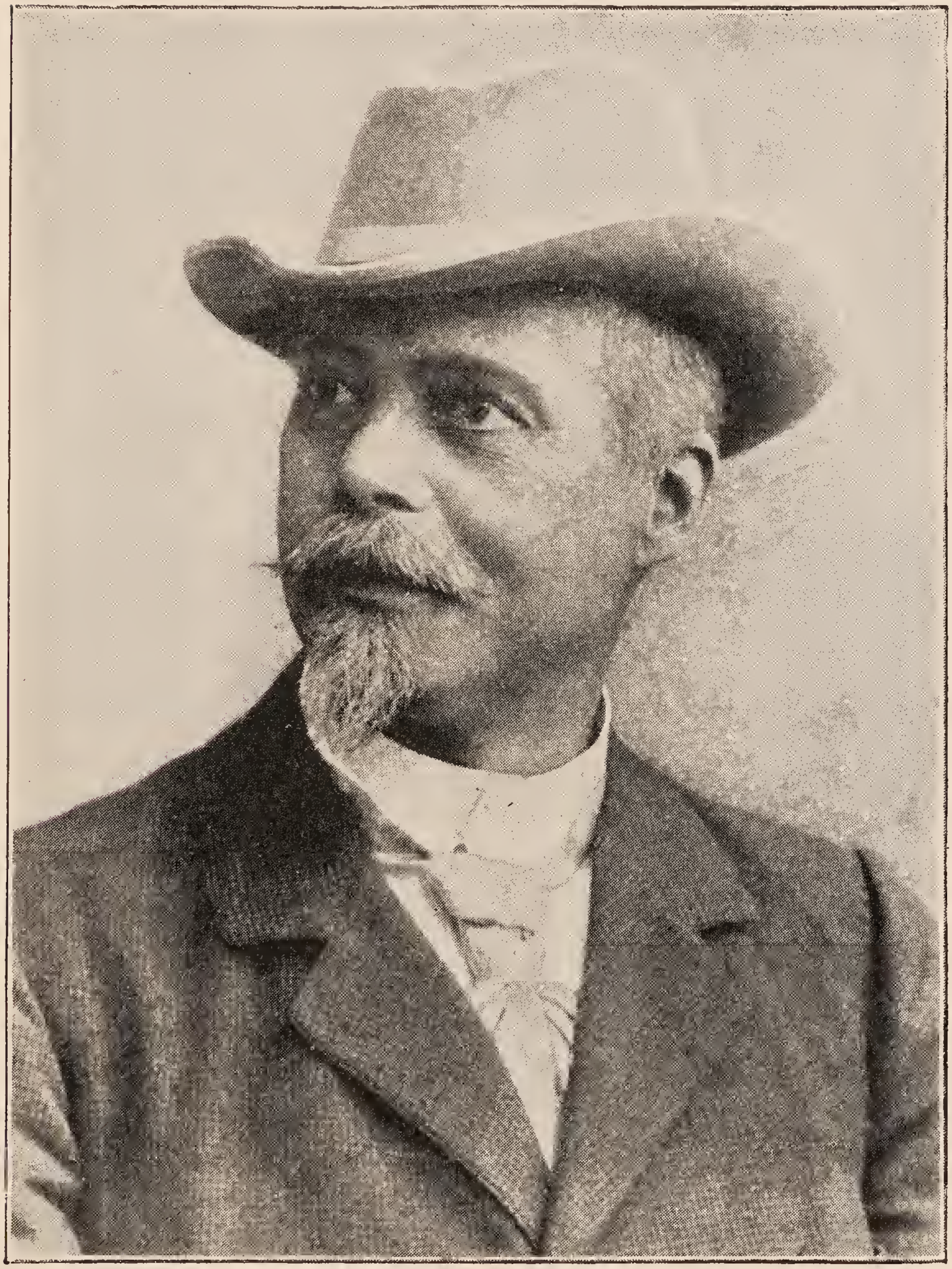


FIG. 194.—R. Wiedersheim (*b.* 1848).

The Evolutionist at Large, Vignettes from Nature, and *Charles Darwin,* being an account of his life and work (English Worthies Series). His early death was a great loss.

Robert Wiedersheim (Fig. 194; *b.* at Nürtingen, April 21st, 1848) is a professor of comparative anatomy at Freiburg and is the author of several learned works, among which *Elements of the Comparative Anatomy of Vertebrates* and *The Structure of Man: An Index to his Past History* (1895) are among the most distinguished. He agrees with Balfour and Dorn in thinking that the fins of fish arise from a fold of skin.

Such are a few of the men whose toil is interpreting the world to man. When we have left our barbarism behind, instead of recording battles we shall mark our calendars by the birthdays of these pioneers of truth.

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